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Cover:. Original figures of *Voluta hannafordi* McCoy and *Voluta strophodon* McCoy. A reproduction of portion of plate XXXVII from Decade IV of Frederick McCoy's *Prodromus of the Palaeontology of Victoria* published in 1876.

The figures were drawn by McCoy's assistant, Arthur Bartholomew, lithographed by Frederick Schoenfeldt, a Swiss artist and lithographer and printed by the Melbourne firm of De Gruchy and Leigh.

The specimens depicted are revised and reillustrated in this *Memoir* as *Livonia hannafordi* (McCoy) and *Nannamoria strophodon* (McCoy).

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Memoirs of the Museum of Victoria 49(2): 195–307 (1988) ISSN 0814-1827

A REVISION OF THE TERTIARY VOLUTIDAE (MOLLUSCA: GASTROPODA) OF SOUTH-EASTERN AUSTRALIA

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Abstract

Darragh, T.A. 1988. A revision of the Tertiary Volutidae (Mollusca: Gastropoda) of south-eastern Australia. *Memoirs of the Museum of Victoria* 49: 195–307.

The Volutidae of Australia consists of 18 genera or subgenera of which five are known only as fossils and three only in the living fauna. (Twenty other genus group taxa have been synonymised.) The fossil genera can be grouped according to their affinity as:

Cosmopolitan: *Lyria* (Late Oligocene–Recent), *Athleta* (Late Paleocene) and *Scaphella (Aurinia)* (Late Eocene).

Endemic (the dominant element): *Livonia* (Late Oligocene–Recent), *Ericusa* (Late Oligocene–Recent), *Nannamoria* (Late Oligocene–Recent) and *Amoria* (Middle Miocene–Recent).

Neozelandic: *Alcithoe (Alcithoe)* (Late Miocene, Late Pliocene), *Alcithoe (Waihaoia)* (Late Eocene–Middle Miocene).

Indo-Pacific or Tethyan: *Cymbiola* (Late Oligocene–Recent), *Mitreola* (Late Eocene) and *Leptoscapha* (Middle Miocene, Recent).

The living volutes of the Southern Australian region are almost entirely derived from the Southern Australian Tertiary volute fauna.

Twenty-two new species group taxa are proposed:

Lyria acuticostulata (E–M Mioc.), *L. mitraeformis crassicosta* (E Pleist.), *Mitreola salaputium* (L Eoc.), *Scaphella (Aurinia) johannae* (L Eoc.), *Notovoluta variculifera* (L Eoc.), *N. capitonica* (L Eoc.), *N. verconis medicata* (E Pleist.), *N. kreuslerae occulta* (E Pleist.), *N. linigera* (E Mioc.), *N. differta* (E Mioc.), *Nannamoria amplexa* (L Mioc.), *N. fasciculata* (E. Mioc.), *N. trionyma* (M Mioc.), *N. paraboloides* (L Mioc.–L Plioc.), *N. deplexa* (E Mioc.), *N. cinctuta* (L Plioc.), *Alcithoe (Waihaoia) pagadoides sororcula* (L Olig.), *A. (W.) neglectoides* (L Olig.), *Alcithoe (A.) orphanata* (L Plioc.), *Livonia mortoni connudata* (E Mioc.), *L. voluminosa* (M Mioc.), *Notopeplum primarugatum* (E Olig.)

Contents

Introduction

Volutidae are carnivorous burrowing molluscs represented in all oceans of the world, but particularly in those of the Southern Hemisphere. The seas surrounding Australia probably have the greatest diversity of genera, and about one third of the described species. Volutes are generally thought of as tropical animals, but, in fact, the majority of species occurs in warm-temperate to temperate waters and some even in the cold waters of the Antarctic and in abyssal depths (Weaver and du Pont, 1970). Distribution with depth ranges from intertidal to abyssal, but most are confined to depths less than 200 metres. The oldest species of the family appear in the Late Cretaceous of North America, Europe, the Middle East and India and the family was well established throughout the world by the Eocene (Wenz, 1943).

In general, this study has shown that the Australian Tertiary Volutidae, by virtue of the distribution of the Tertiary rocks, is similar to that presently found in temperate to warm-temperate waters of the southern half of the Australian Continent and distributed between 0 and 250 metres. They range in size from the 9 mm *Leptoscapha crassilabrum* (Tate) to the 300 mm *Livonia hannafordi* (McCoy).

Owing to their beauty and diversity, the Australian living volutes attracted the attention of professional and particularly amateur conchologists for many years. Much has been written on the group but there has been no serious attempt to analyse the fauna as a whole and relate it to the fossil record. The most comprehensive account of Australian Recent volutes is that of Weaver and du Pont (1970) who monographed the Volutidae of the World. However, whilst their work will remain a classic study of the family, they could not, of necessity, treat the Australian members in detail, particularly with reference to status of genera, and they did not touch on the geological history of the family. Nevertheless, their work brings together the widely scattered literature, provides up-to-date information, excellent figures of the living species, and is of considerable assistance to workers on the family.

The fossils, on the other hand, received a minimum of attention. Apart from the original descriptions of species, there has been little further work, and no attempt at systematic revision or proper synthesis of the Tertiary and Recent faunas. The work reported here has involved a systematic study of the entire fossil fauna at both the generic and specific levels and an attempt has been made to elucidate the geological history of the group and to integrate fossil and living species. The palaeontologist, if the geological record is good, sometimes has an excellent opportunity to study the variations in morphology of a group, since he is dealing with organisms which range through time as well as in space; hence he may have a better appreciation of range of variation and relationships within a genus than the worker on living species.

There are several factors which hitherto tended to prevent a critical appraisal of the volute family as a whole. Firstly, excessive taxonomic splitting, particularly at the generic level, mainly by workers on living species, lead to the creation of monotypic genera, obscurred relationships and articially differentiated between living and fossil species by inflation of the living fauna. Secondly, many of the Tertiary species, such as those of *Notopeplum, Notovoluta* and *Ternivoluta*, belong to groups at present found in moderately deep water, beyond the reach of normal collecting and it is only in recent years with the development of trawling that species, such as *Nannamoria parabola, Ternivoluta studeri* and *Notopeplum translucidum* have become readily available for study and comparison with Tertiary species. Thirdly, previous workers on volutes have tended to be wholly involved either with fossils, or with living species and have not

made more than token comparisons between the two groups.

In this revision, the genera of Recent volutes receive considerable attention but the species are not dealt with in detail in view of the work of Weaver and du Pont (1970). The species of volutes of Southern Australia are assigned by the author to 18 genera or subgenera, of which five are known only as fossils. there are two further taxa, *Volutoconus* and *Melo*, known only from Northern Australia doubtfully recorded as fossils and another, *Lyrenaeta,* not known in the fossil record, which are mentioned only in passing. Twenty genus-group taxa have been sunk in synonomy with one or other of the 18 recognised genera. *Teramachia*, recently recorded from north-western Australia, is not regarded by the author as a member of the family. Though its familial relationship is uncertain, because the anatomy of the animal is unknown, the author suggests that it would be better placed in the Turbinellidae pending examination of the animal. Even so, the Australian volute fauna is the most diverse in the world and because of this diversity both at generic and specific levels, the Volutidae is potentially an exceedingly useful family for stratigraphical purposes in this country. Many species have short time ranges and are easily recognisable. Volutes are found in a wide range of depths and on a variety of substrates. In the Tertiary sequence of south-eastern Australia fossil volutes are, therefore, found in many different kinds of rocks throughout the stratigraphical column.

Previous work

The original authors of the many Australian fossil species of volutes described in the nineteenth and early twentieth century, McCoy (1866, 1874, 1876), Tenison Woods (1876), Johnston (1880, 1888), Tate (1888, 1889b) and Pritchard (1896, 1898, 1913), described their species, with the exception of those in *Lyria* under the old Linnaean name *Voluta,* despite the fact that several other generic names had already been used for some of the living species from Australia. Tate (1889) did use *Amoria* and *Volutoconus*, but only as sections rather than as subgenera. Harris (1897) distributed 19 of the described species known to him, in eight genera or subgenera, with a measure of success, by using the form of the protoconch as a guide, in the manner advocated by Dall (1890b). Tate (1898) stated that Harris's classification did not meet all the requirements and he offered the first overall classification of the entire group of fossils. He distributed 32 species in two genera, *Volutilithes* and *Voluta,* the latter having nine sections. *Lyria* was not mentioned. His proposal was a distinct advance and much of his grouping still stands, though with a few modifications owing to changes in nomenclature. Cossmann's classification (1899) made only minor alterations to that of Tate but did not include all species.

Finlay (1927, 1930) and Marwick (1926), when dealing with New Zealand fossil and living volutes, made occasional references to Australian fossil species. Cotton (1949) proposed a comprehensive classification of the Tertiary and Recent species; however, he accepted uncritically all genera and species described to that time. He listed 79 living and 48 fossil species in 22 genera. Later authors, Ludbrook (1958), McMichael (1959, 1960, 1961) and Wilson (1972) have dealt with or mentioned various species and genera, but have made no overall revision or review.

Composition and origins of the Australian volute fauna

The composition of any volute fauna in any region will depend, to some extent, on the mobility, or otherwise, of particular species. As adult volutes are benthic animals with little mobility, one must look to the larvae for possible means of dispersal. Little is known of the larval development of the various species, particularly those from deep water; however, of those species for which this information is available (Wilson, 1971) all have direct development and no planktonic or free-swimming larval stage. Therefore their means of dispersal is limited and leads to genetic isolation and hence considerable intra-specific variation, a feature which has already been mentioned by McMichael (1959), and Wilson (1971). This also leads to marked provincialism among volutes since trans-oceanic dispersal is greatly inhibited. Thus with few exceptions, genera are not widely distributed and at present are restricted to epi-continental areas or larger islands (Kay, 1967). In fact the volute fauna of the areas where species occur today was largely established by mid-Tertiary time and little has been added since. This generalisation is true only for the areas which have a reasonable fossil record and a living volute fauna.

These are as follows:

Japan: *Fulgoraria* and its allies range from Oligocene to Recent.

Central America: *Voluta* Miocene to Recent, *Scaphella* Miocene to Recent, *Mitreola* (= *Enaeta*) Miocene to Recent.

South America: *Adelomelon* Miocene to Recent, *Pachycymbiola* Miocene to Recent, *Miomelon*

Miocene to Recent.

New Zealand: *Waihoaia* Eocene to Miocene, *Alcithoe* Miocene to Recent.

Australia: *Ternivoluta* Eocene to Recent, *Notovoluta* Eocene to Recent, *Ericusa* Oligocene to Recent, *Livonia* Oligocene to Recent, *Notopeplum* Eocene to Recent, *Amoria* Miocene to Recent, *Nannamoria* Oligocene to Recent.

The only truly cosmopolitan genera are *Athleta, Lyria* and their allies which in the early Tertiary make up a large proportion of the volute fauna of the world. A possible inference from this is that the cosmopolitan genera had planktonic larval stages at least in the early Tertiary and that direct development which lead to the marked provincialism evolved in the middle Tertiary.

The genera in the Australian fauna recognised by the author, their synonyms, time ranges and number of species or subspecies in Australia are summarised below. Further details will be found under the systematic descriptions of each of the taxa.

Athleta (Athleta). Late Paleocene (Numerous synonyms, Darragh, 1971). A single species is known similar to those present in the early Tertiary of Europe. The genus had virtually a cosmopolitan distribution in the Paleogene, became more restricted during the Neogene and at present is confined to the Indian and Atlantic Oceans off the coast of Southern Africa.

Athleta (Ternivoluta). Late Eocene–Recent (= *Austrovoluta*). Ten specific taxa, two of which are living. An endemic subgenus, derived from *Athleta (Athleta)* in the Eocene, is well represented throughout the Tertiary of South-eastern Australia but is now confined to small areas in deep water off the central east coast of Australia (Darragh, 1971, 1979).

Lyria. Late Oligocene–Recent (= *Harpeola*). Twelve specific taxa, 3 of which are living. *Lyria* is probably derived from a member of the Athletinae in the Late Cretaceous. It was established by the Paleocene and in the Eocene had virtually a cosmopolitan distribution. The present distribution is much more restricted, as it is now confined to the tropical and temperate West Pacific and Indian Oceans and the Western Atlantic. The Australian species appear to be most closely related to Eocene species of the Paris Basin and Oligocene–Miocene species of South-eastern Asia.

Lyrenaeta, a monotypic genus, is restricted to central and northern New South Wales. Specimens are rare. The genus is closely related to *Lyria* and the Southern African *Callipara*, but there are no obvious ancestors in the fossil record.

Leptoscapha. Middle Miocene, Recent. The single species known appears to be closely related to the type species from the Middle Eocene of the Paris Basin and another species from the Late Eocene of Java.

Mitreola. Late Eocene (= *Enaeta*). A single species of the genus is known from South-west Australia. The genus was established in Europe in the Paleocene and became extinct there in the Oligocene. It reached the American region in the Early Miocene and is now confined to the Central American region.

Scaphella (Aurinia). Late Eocene. The single species known is similar to those present in the early Tertiary of Europe. The subgenus ranges in Europe from Paleocene to Pliocene. In America, it appears in the Miocene and is now confined to the coasts of eastern central America.

Alcithoe (Waihaoia). Late Eocene–Middle Miocene. Seven specific taxa known of which three make up a group of related taxa. The other four seem to be closely related to New Zealand species of the genus rather than to the other Australian species. The genus may have arrived in Australia from New Zealand in the Early to Middle Eocene, however the taxon is not known in New Zealand prior to the Middle Eocene.

Alcithoe (Alcithoe). Late Miocene, Late Pliocene (= *Leporemax, Carolluta, Gilvostia*), two species. The origin and relationships of each of these species are obscure, but they seem to be closely related to New Zealand species rather than to one another. There is no unbroken record of the taxon through the Southern Australian Tertiary and each species may represent a separate migration from New Zealand.

Ericusa. Late Oligocene–Recent (= *Mesericusa.*) Eleven specific taxa, four living of which two are known as fossils. This taxon and *Livonia* are closely related and presumably had a common origin in the Eocene or early Oligocene.

Livonia. Late Oligocene–Recent (= *Mamilla, Pterospira, Cottonia*), 12 specific taxa, five living of which one is known as a fossil.

Notopeplum. Late Eocene–Recent. Six specific taxa, two living, one of which is known as a fossil. An endemic Southern Australian genus whose origins are obscure, but it seems to be related to *Livonia* and *Ericusa.*

Cymbiola. Late Oligocene–Recent (= *Aulica, Aulicina, Cymbiolena, Cymbiolacca*). About 14 specific taxa are currently recognised in Australia but revision will probably cut this figure to about 10. Most species are found in Northern Australia. In the south, three species are known, of which two

are known only as fossils and the other occurs living in Western Australia and as a fossil in South-eastern Australia. There are numerous other taxa throughout the Indonesian and Philippine Islands. The genus ranges from Late Miocene to Recent in the former area.

Melo. Pliocene–Recent (Indonesia) (= *Melocorona*). This genus, known from the Neogene of Indonesia and doubtfully from the Middle Miocene of North Western Australia, is not represented in the fossil record of the Southern Australian Region. It is well established in the Northern Australian Region and has penetrated as far south as Victoria, presumably arriving in the Late Pliocene or the Pleistocene. This genus is closely related to *Cymbiola*.

Amoria. Middle Miocene–Recent (= *Amorena, Relegamoria, Cymbiolista, Zebramoria*). Four fossil taxa, two of which are still living. Several other species occur around the Australian coast, particularly in the north and extending into the southern islands of Indonesia. The known fossils are of species with southern affinities. The history of the genus is obscure, however as there is no fossil record in the Neogene of Indonesia, the genus may have its origin in the Australian Tertiary.

Nannamoria. Late Oligocene–Recent (= *Paramoria*). Seventeen specific taxa of which five are living. An endemic genus widely distributed in the southern Australian Region and common in the Tertiary of South-eastern Australia. The origin of the genus is not clear. On the basis of shell characters, a possible relationship with *Cymbiola* and *Notovoluta* is suggested.

Notovoluta. Late Eocene–Recent. Seventeen specific taxa, six living, of which one is known as a fossil. This is another endemic genus whose origin is obscure.

Volutoconus. No fossil record in the south but doubtfully recorded from the Middle Miocene of North-west Australia. Four specific taxa in Northern Australia. Judging from shell characters, the genus is related to *Cymbiola*, but the radula is unusual and allies it with the South American genera *Miomelon and Odontocymbiola*.

The fossil fauna

The fossil fauna is composed of four groups of genera defined by their origin or affinity. These are as follows:

1. Cosmopolitan Element represented by *Lyria, Athleta* sensus lato and *Scaphella (Aurinia)*.

2. Endemic Element which is dominant and represented by *Livonia, Ericusa, Notopeplum, Notovoluta, Nannamoria* and *Amoria*.

3. Neozelandic Element represented by *Alcithoe (Alcithoe)* and *A. (Waihaoia)*.

4. Indo-Pacific or Tethyan Element represented by *Cymbiola, Mitreola* and *Leptoscapha*.

The representatives of the first group, whilst once widespread, particularly in the Paleogene, are now more restricted in their distribution. Those of the second group make up the major part of the Southern Australian living fauna, but *Amoria* is a prominent element of the Northern Australian Region. The third group is now confined to the waters surrounding New Zealand and is not now represented in the Australian fauna. Both the second and third groups, in part, belong to Fleming's (1962, 1963) Paleoaustral Element. The genera *Livonia, Ericusa, Notopeplum, Notovoluta (?)* and *Alcithoe* are most probably related to the Southern American genera *Zidona, Adelomelon* and *Proscaphella*. Of the last group (4), only *Cymbiola* is still extant and is characteristic of the present Northern Australian fauna, but there are still some representatives of the genus in Southern Australia, particularly in the Overlap Zones between the Southern Australian Region (temperate) and the Northern Australian Region (tropical).

It can be argued that some of the genera cited above had their origin in the Southern Australian Region and subsequently colonised other areas, but the fossil record in the north is so poor in Volutidae that it is not possible to support or disprove this argument. *Cymbiola*, for instance, is known only from the Late Miocene and Pliocene in the Indonesian archipelago and from the Middle Miocene of North-west Australia, whereas, in Southern Australia, the first record is from the late Oligocene. Specimens are uncommon, however, and the evidence suggests that South-eastern Australia was a marginal area in the distribution of the genus.

For a general discussion of the composition of the fossil fauna see Darragh (1985).

The living fauna

The Volutidae of Australia can be conveniently divided into two groups, both of which fall neatly into the two biogeographic regions proposed by Wilson (1971) on the basis of general molluscan distribution, the Northern Australian or Tropical Region and the Southern Australian or Temperate Region. Between these two regions are two areas which Wilson calls the Western and Eastern overlap zones, extending respectively from Northwest Cape south to Cape Leeuwin and from Fraser Island south to Cape Howe. In these there is an overlap or transition between the two faunas.

Volute genera characteristic of the Southern Aus-

tralian Region are *Notovoluta, Livonia, Ericusa, Notopeplum* and *Nannamoria,* all of which are well represented in the Tertiary of Southern Australia and are not known elsewhere. The Northern Australian Region is characterised by *Volutoconus* and *Melo* which are not known as fossils in the south (records of *Volutoconus* are not correct, see below), and by *Amoria* and *Cymbiola* which are poorly represented in the fossil record of the south. Both *Melo* and *Cymbiola* are represented in the Late Tertiary of the Indonesian Archipelago. The two overlap zones have representatives of both groups.

This study shows that the volutes of the Southern Australian Region are almost entirely derived from the Southern Australian Tertiary fauna, whereas those of the Northern Australian Region belong to the western Indo-Pacific fauna and seem to have their origins in the Tethyan fauna of Fleming (1967) and Ludbrook (1954), the volutes of which unfortunately are not well documented, particulary prior to the Pliocene.

Classification

The classification of the Volutidae currently accepted by most workers is essentially that of Pilsbry and Olsson (1954). These authors reviewed in some detail previous attempts to classify the genera of the family and then proposed their own classification. They divided the family into twelve subfamilies on the basis of radula, where known, and shell characters, particularly the nature of the protoconch. One subfamily included, the Volutomitrinae, is now regarded as a family in its own right (Ponder, 1972) and is excluded from discussion. Later, Clench and Turner (1964) examined the anatomy of many American species of volutes, slightly modified the classification, but confirmed the subdivisions at least for the groups they examined. Weaver and du Pont (1970) accepted the classification, but Turner, who contributed new anatomical data to their monograph, expressed doubts on the placement of some taxa, particularly in regard to some of the Australian genera, such as *Amoria* and *Ericusa.*

The writer, in association with B.J. Smith, has completely reassessed the subfamilies and the placement of genera on the basis of previously published anatomical data (listed in Weaver and du Pont, 1970) and on personal examination of the anatomy of specimens of over 30 nominal taxa of Australian volutes (see Appendix 2). The principal features used by Clench and Turner (1964) to characterise the subfamilies, namely, radula, siphon and anterior digestive system, have also been used in this study, together with the presence or absence of an operculum and the nature of the head lobe, to produce a new classification in which the generic arrangement differs considerably from that of Weaver and du Pont (1970).

The classification followed in this work is outlined below and lists the Australian genera recognised by the writer. Further details and diagnoses of the subfamilies can be found under the appropriate subfamily in the systematic section.

Athletinae: *Athleta (Athleta), Athleta (Ternivoluta).*

Volutinae (= Lyriinae, Volutilithinae, Calliotectinae): *Lyria, Leptoscapha, Mitreloa, Lyrenaeta.*

Scaphellinae: *Scaphella (Aurinia).*

Subfamily uncertain: *Notovoluta, Volutoconus.*

Amoriinae: *Amoria, Nannamoria.*

Zidoninae: *Alcithoe (Alcithoe), Alcithoe (Waihaoia), Ericusa, Livonia, Notopeplum, Cymbiola, Melo.*

Stratigraphical record in South-eastern Australia

The fossil record of Volutidae in South-eastern Australia is rather fragmented owing to facies changes in Tertiary sediments and lack of appropriate outcrop. These aspects have been discussed in more detail by Darragh (1985) and are only outlined here.

The Paleocene and Early to Middle Eocene are represented by a series of shallow-water marine or non-marine sediments in which volutes are either absent or rare. The single undoubted volute species known, *Athleta (Athleta) wangerrip* Darragh, may be ancestral to the Late Eocene to Early Oligocene *Athleta (Ternivoluta) curvicostata* Darragh. The Late Eocene sediments are of open marine origin and though reasonably widespread, outcrop is limited.

Early Oligocene marine sediments are also limited in outcrop. The volute fauna of the Late Eocene and Early Oligocene is meagre and it is not until the Late Oligocene through to Middle Miocene that the volute fauna is rich. During this latter period moderately deep neritic sediments were deposited across Southern Australia and outcrop of these sediments, in general, is excellent.

The volute fauna of the Late Miocene through the Pliocene to the Pleistocene is rather poor, since sediments of this age are mostly of shallow-water origin and volutes, apart from *Amoria*, are rare. There are also numerous breaks in the sequence, particularly in the Late Pliocene, so that a continuous record of volutes is not possible.

Notwithstanding problems of limited outcrop and lack of sediments of appropriate facies, the members of the family are extremely useful

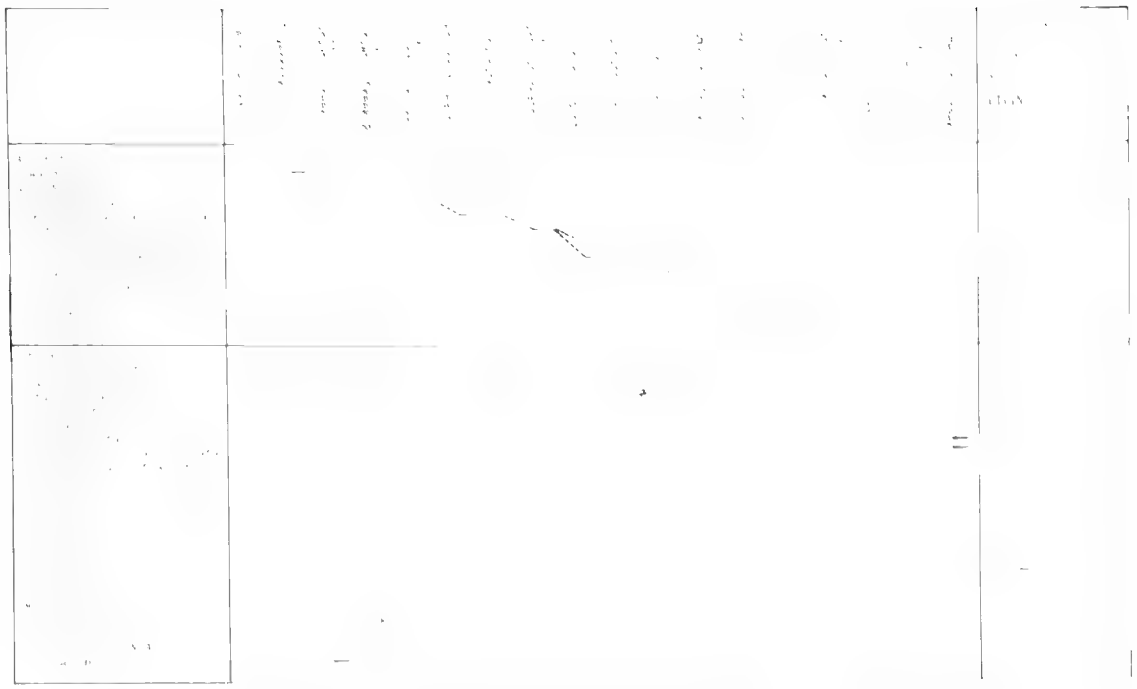

Table 1. Ranges of volute species in terms of molluscan assemblages. denotes occurrence of taxon in strata of equivalent age in South Australia and Western Australia (continued on next page).

stratigraphically within the period for Late Eocene to Early Pliocene. (Table 1). Within certain genera it is possible to demonstrate lineages of species which are particularly useful for fine stratigraphical subdivision.

To establish a lineage of taxa it is necessary for the taxa to be similar in morphology and succeed one another closely in time. In theory, there should be a continuous record of morphological change with time. In practice, lineages are very difficult to establish and document beyond reasonable doubt, owing to the fickle nature of the fossil record, and only small sections of the continuum are preserved. Variables, such as geographical distribution of outcrops, nature of outcrops, richness of outcrops, facies of sediments preserved or outcropping, disconformities and lack of continuous sections, contribute to the problem and prevent lineages being recognised. In South-eastern Australia from the Late Eocene to Middle Miocene, but particularly from Late Oligocene to Middle Miocene, it is possible to control some of these variables and suggest possible lineages. In this part of the stratigraphical column there are sufficient localities to compose a composite section of reasonably uniform lithology which have yielded material to document five lineages. These occur within the genera *Nannamoria, Notopeplum, Notovoluta* and the subgenus *Ternivoluta*. It can be shown for each of the proposed lineages that certain morphologically similar taxa succeed one another within short intervals of time in a reasonably uniform succession of clastic sediments and in a geographically restricted area, the Otway Basin. In each case there are no other morphologically similar taxa in the sediments concerned and the simple and most reasonable explanation for the succession of these closely related taxa is to assume that the older taxa gave rise to the younger.

Terminology

Species descriptions are arranged within genera in approximate order of their appearance in the stratigraphical record. Measurements are given as follows: L, Total length of shell from tip of protoconch to end of anterior canal along the axis of the shell; HA, Height of aperture from suture to end of anterior canal, measured parallel to the axis of the shell; W, Width of shell measured perpendicular to the axis of the shell and between any axial sculpture.

Localities are abbreviated and listed under locality numbers, e. g., FI.82, Clifton Bank, a key to which can be found as Appendix 1. Grid references are given in brackets throughout.

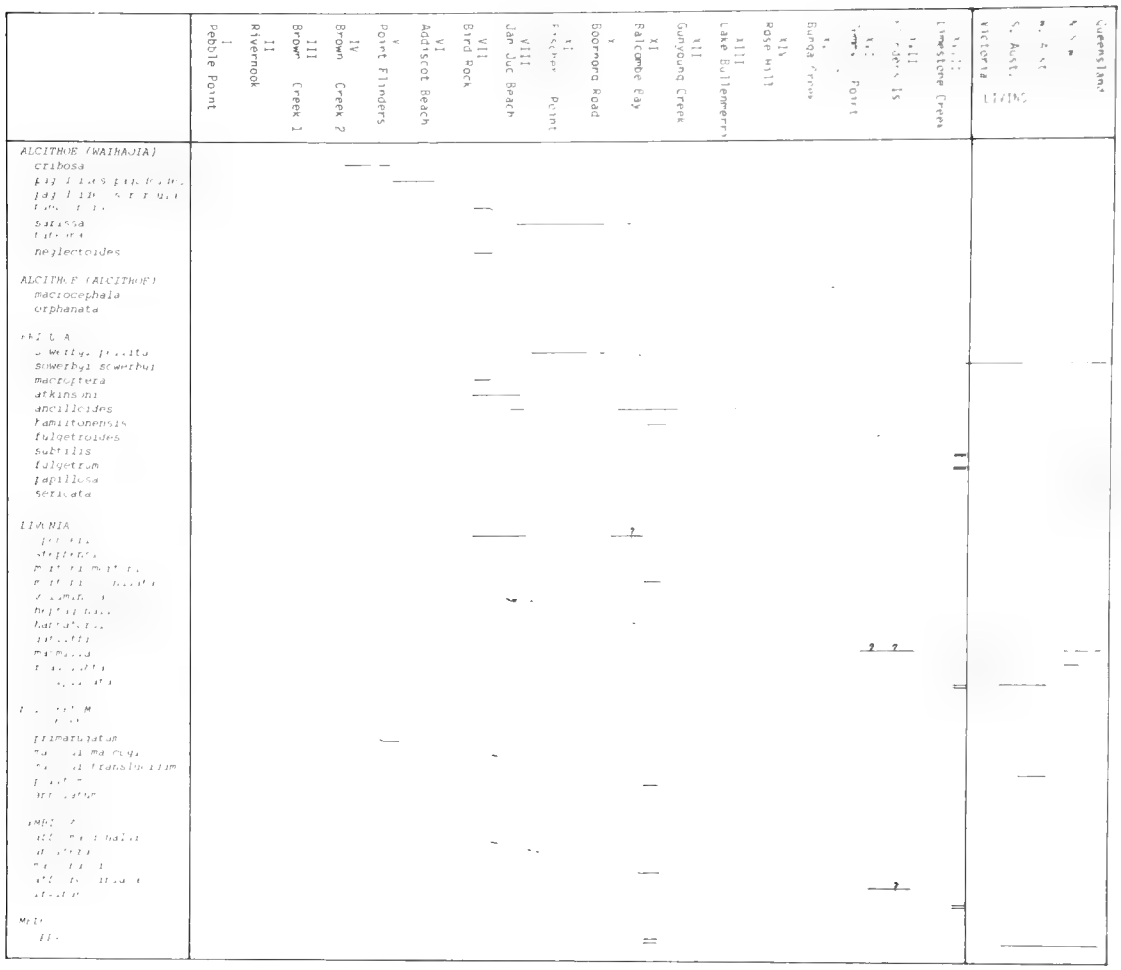

Table 1 (continued). Ranges of volute species in terms of molluscan assemblages. = denotes occurrence of taxon in strata of equivalent age in South Australia and Western Australia (continued on next page).

Systematic Palaeontology

Volutidae Rafinesque, 1815

Diagnosis. Shell: Shell ovate to fusiform, ranging in size from small (10 mm) to very large (500 mm), often coated with a smooth, highly polished glaze. Sculpture, if present, highly variable, consisting either of axial or radial elements and sometimes both. Protoconch generally smooth, usually calcareous, but chitineous and deciduous in some groups, sometimes multiwhorled and coiled with axis of shell, but generally of 1 to 3 whorls, the first of which may be deviated from axis of shell. Aperture elongate, usually about a third length of shell and produced into a short, but well defined anterior canal, having in most groups a siphonal notch and fasciole, which if present vary in degree of development. Outer lip of aperture generally simple and slightly thickened, but produced laterally into a pronounced wing in some groups. Plaits highly variable in number, sometimes absent, but generally 3 to 5 strong plaits are present, which may have numerous weaker plaits inserted between or posterior to them. Shell generally highly coloured with variable colour patterns.

Animal: Foot large and broad. Head wide and flattened, usually with a large central lobe, which in some groups is divided by a median cleft, and 2 lateral lobes on which are situated 2 flattened triangular tentacles. Eyes, if present, usually behind and at base of tentacles. Siphon large, overlying head, with 1 or generally 2 lateral lobes or appendages at base. Mantle in some groups large and capable of enveloping shell. Mantle, siphon, proboscis

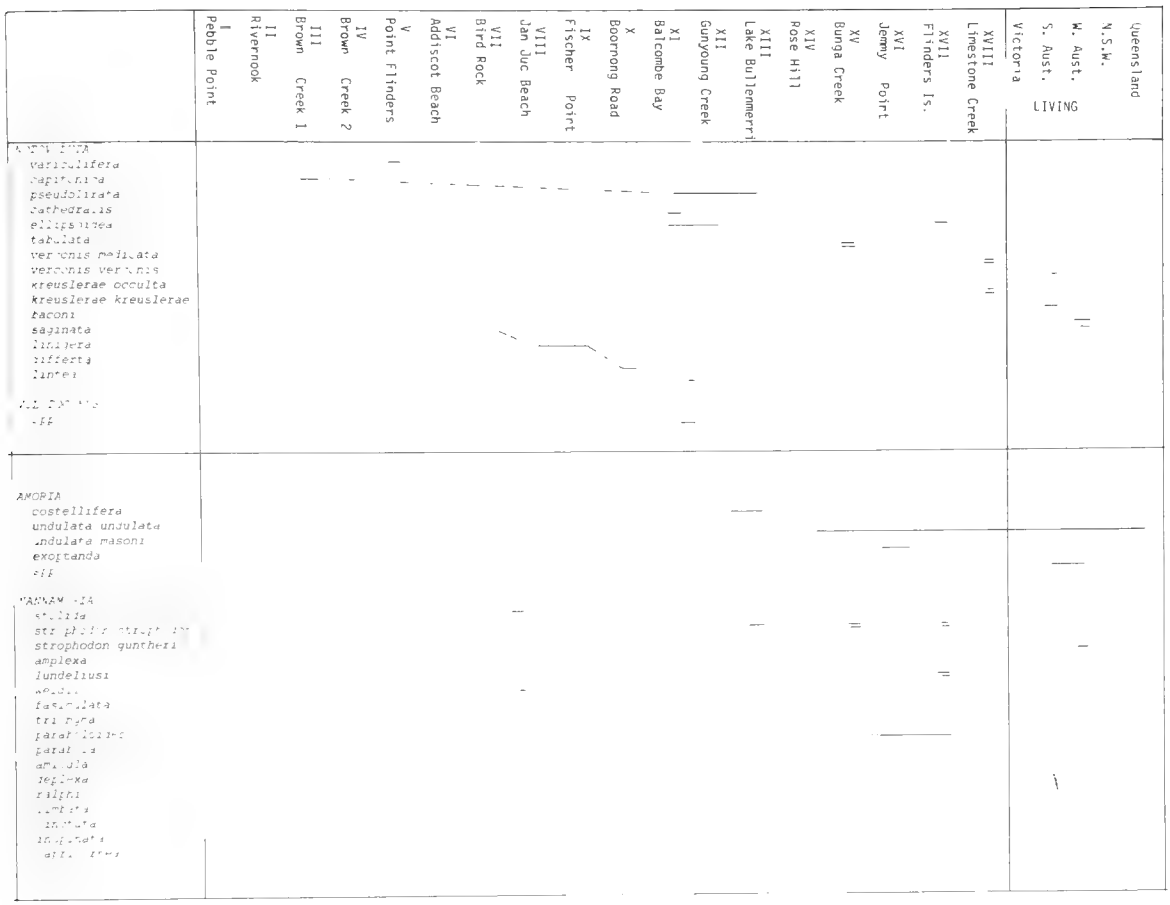

Table 1 (continued). Ranges of volute species in terms of molluscan assemblages. = denotes occurrence of taxon in strata of equivalent age in South Australia and Western Australia.

sheath and foot highly coloured, usually complementing colour of shell.

Proboscis present. Radula normally uniserial, with tricuspid, rarely unicuspid or multicuspid teeth; when present lateral teeth simple and weakly developed.

Males usually with a long penis folded back into mantle cavity. Vas deferens in some groups imbedded in body wall, in others an open pallial groove.

Athletinae Pilsbry and Olsson, 1954

Diagnosis. Foot broad, flat, entire. Head bilobed, divided by a prominent median cleft and laterally produced into 2 tentacles behind which are prominent eye stalks. Siphonal appendages absent or very weakly developed. No operculum. Tubular salivary gland separated from the racemose salivary gland. Radula triserial with a central row of small tricuspid teeth and small unicuspid laterals.

Remarks. The subfamily Athletinae is represented in Australia by *Athleta* s.s. and the subgenus *Ternivoluta,* the species of which have been discussed by Darragh (1971, 1979). Since this work was published, the only important addition to record for this subfamily is the finding of a specimen of *Athleta (Ternivoluta) curvicostata* Darragh at locality FL11 in the lower part of the Brown Creek Formation, which extends the range of this species and that of the genus into the Late Eocene.

Volutinae Rafinesque, 1815

(= Lyriinae Pilsbry and Olsson, 1954, Volutilithinae Pilsbry and Olsson, 1954, Calliotectinae Pilsbry and Olsson, 1954).

Diagnosis. With a horny operculum. Head bilobed with triangular lobes posterior to the eyes. Siphonal appendages unequal with the left longer and flatter, right appendage occasionally absent. Tubularly salivary gland of the anterior digestive system usually short and free from the racemose salivary gland. Radula uniserial, though rarely with vestigial laterals, rachidean tricuspid but occasionally mul-

ticuspid. Shell characters variable. Plaits absent or numerous with the anterior 2 the stronger.

Remarks. The subfamily Volutinae, as recognised herein, embraces certain genera not assigned to it by Pilsbry and Olsson (1954), as well as those genera which they placed in the Lyriinae, Volutilithinae and Calliotectinae. They are listed below. This present grouping is based on observations which show that the anatomical details of the living species e.g. *Lyria cordis, L. deliciosa, Neptuniopsis gilchristi, Calliotectum vernicosum* of these genera are all similar and unlike the majority of the other genera of the Volutidae, particularly in having an operculum and a bilobed head.

Those genera previously placed in the Lyriinae are difficult to separate from *Voluta* s.s. on shell characters (Gardner, 1935) and the only obvious difference is in the radula, which is multicuspid in *Voluta*, and was the basis for separating the other volutes from the Volutinae. However, *Voluta virescens* Lightfoot has its central and terminal cusps stronger than the others (Bayer, 1971, fig. 60B) and *Lyria cordis* Bayer is tricuspid with a series of small denticulations between the cusps, suggesting that the presence or absence of denticulations is of specific or perhaps generic significance, rather than of subfamily significance. A similar variation in radular pattern is found in the Scaphellinae (Clench and Turner, 1964; Bayer, 1971). Bayer has commented on the interspecific variation of the radula and points out that this may be related to the development of specialised feeding habits. Hoerle and Vokes (1978) also pointed out that *Falsilyria* Pilsbry and Olsson (1954) morphologically is intermediate between *Voluta* and *Lyria*. In view of this and the close similarity of the anatomy of *Lyria* and *Voluta* (Bayer, 1971) there are no grounds for maintaining them in separate subfamilies.

With respect to those genera placed in the Calliotectinae, it is obvious on the basis of anatomy and radula (Dall, 1980a; Woodward, 1900; Pace, 1902) that they are closely related to *Voluta* and *Lyria* and not to any other volutes. The obvious differences are in shell characters, which appear to be functional modifications for life in deepwater. In general most deep water volutes lack columella plaits or have few weakly developed plaits. The vestigial laterals of the radula are reminiscent of those found in *Lyria* and *Festilyria*.

The grouping outlined above brings together all the known operculate volutes with the exception of *Saotomea*. The anatomy of this genus is unknown, though its shell characters resemble *Fusivoluta*, and currently it is placed in the Fulgorariinae, however, subsequent study of the anatomy may show that it too would be better placed in the Volutinae.

The genera included in the subfamily Volutinae by the writer are as follows:

Voluta Linnaeus, 1758 (anatomy described Clench and Turner, 1964).

Pseudaulica Furon, 1948 (probably a synonym of *Voluta*).

Falsilyria Pilsbry and Olsson, 1954.

Chiraluta Olsson, 1931.

Woodsivoluta Pilsbry and Olsson, 1954 (probably a synonym of *Chiraluta*).

Peruluta Olsson, 1928.

Calliotectum Dall, 1890 (anatomy described Dall, 1890a.)

Neptuneopsis Sowerby, 1898 (anatomy described Pace, 1902; Woodward, 1900).

Fusivoluta Martens, 1902 (anatomy described Rehder, 1969; Kilburn, 1971).

Lyria Gray, 1847 (= *Harpeola* Dall, 1907, *Sannalyria* Pilsbry and Olsson, 1954, *Paralyria* Shuto, 1962).

Cordilyria Bayer, 1971, (anatomy described Fischer, 1867; Bayer, 1971; Cosal and Blocher, 1977).

Mitreola Swainson, 1833 (= *Enaeta* H. and A. Adams, 1853).

Lapparia Conrad, 1855.

Harpulina Dall, 1906.

Festilyria Pilsbry and Olsson, 1954 (possibly a synonym of *Harpulina*; anatomy described Turner in Weaver and du Pont, 1970).

Volutilithes Swainson, 1829.

Pseudolyria Martin, 1931.

Ctenilyria Woodring, 1964, (possibly a synonym of *Pseudolyria*).

Leptoscapha Fischer, 1883.

Lyreneta Iredale, 1937.

Callipara Gray, 1847.

Notoplejona Marwick, 1926, included by Pilsbry and Olsson (1954) in their Lyriinae, has been shown (Darragh, 1971) to be a synonym of *Athleta* (Athletinae).

Comments on the above list. Discussion of the synonyms of *Lyria* and *Mitreola* is given below following the descriptions of those genera .

The genus *Harpulina* Dall, 1906 (= *Harpula* H. and A. Adams, 1953 non Swainson, 1831) with *Voluta arausiaca* Lightfoot as type species, was grouped with *Alcithoe* by both Pilsbry and Olsson (1954) and Weaver and du Pont (1970). However, comparison of specimens of the type species with illustrations of *Lyria cloveriana* Weaver shows that

these two taxa cannot be separated on shell characters and can thus be regarded as congeneric.

The apertural features of *Harpulina* are similar to *Lyria* so that both belong in the same subfamily. Furthermore there is the possibility that *Harpulina* and *Festilyria* Pilsbry and Olsson, 1954 are related or even synonymous, as species of these two genera have much in common. The latter genus was placed in the Fulgorariinae by both Pilsbry and Olsson (1954) and Weaver and du Pont (1970), though the latter authors pointed out the resemblance of the shell characters to *Voluta* s.s. However, Kilburn (1971) placed two species, *Voluta ponsonbyi* Smith and *V. africana* Reeve, which were previously referred to *Festilyria*, in *Lyria* on the basis of the radula and shell morphology. Certainly the presence of an operculum, the nature of the radula and the apertural features all point to *Festilyria* as a close relative of *Lyria*, but the overall shell characters appear to be distinctive, particularly the wide nodulose shoulder which is not present in *Lyria* s.s. Therefore these species are retained in *Festilyria* and the genus placed in the Volutinae next to *Harpulina*.

Volutilithes Swainson, 1829, which was placed with *Lapparia* Conrad, 1855, in a separate subfamily Volutilithinae by Pilsbry and Olsson (1954), is also very close to *Festilyria* in shell characters. The type species of the genus *V. muricinus* (Lamarck) has shouldered whorls, strong ribs and apertural features identical to *Festilyria festiva* (Lamarck), the type species of *Festilyria*. In fact there are few shell characters to separate them and *Festilyria* and possibly *Harpulina* may well be synonyms of *Volutilithes*. *Lapparia* seems to be the Western Hemisphere analogue of *Volutilithes* and as the apertural features are similar to *Mitreola* it is placed in this subfamily. The close affinity of *Lapparia* and *Mitreola* has already been discussed by Stenzel and Turner (1940).

Callipara Gray, 1847 was placed in the Cymbiinae by Pilsbry and Olsson (1954), and they were followed by Weaver and du Pont (1970) who provisionally placed the genus in that subfamily on the basis of the appearance of the protoconch and columella plaits. However the shell characters of the type and only species in the genus *C. bullatiana* Weaver and du Pont are similar to those found in species of *Lyria*, as noted by Cossmann (1899) and to those of *Lyreneta laseroni* Iredale, so that until the radula and anatomy are known a place in the Volutinae seems more appropriate. Both *Callipara* and *Lyreneta* bear some resemblance to *Harpulina*.

The genera of the Volutinae were distributed throughout the area of Tethys and adjacent seas in Tertiary time, however those species surviving at present have a relict distribution mostly marginal to the Tethys area. The only genera of the subfamily present in the Tertiary of South-eastern Australia are *Lyria* and *Leptoscapha*. *Mitreola* occurs in the Late Eocene of South-western Australia. *Lyria, Leptoscapha* and *Lyreneta* are the only genera represented in the living fauna of the continent.

Lyria Gray, 1847

Lyria Gray, 1847:141.
Lyria (Lyria).—Adams and Adams 1853: 166.
Lyria.—Gray 1855a:16.
Lyria (Harpella) Gray, 1855a: 17 (non Schrank, 1802 (Lepidoptera)).
Lyria (Harpella).—Adams and Adams 1858: 618.
Lyria.—Stoliczka, 1867: 96.—Crosse, 1866: 111.—Tryon, 1882: 101.—Fischer, 1884: 610.—Cossmann, 1889: 197.—1899: 113.
Lyria (Lyria).—Dall, 1907: 350.
Lyria (Harpeola).—Dall, 1907: 350.
Lyria.—Marwick, 1926: 271.—Peyrot, 1928: 339.
Lyria (Lyria).—Theile, 1929: 348.
Lyria (Harpella).—Theile, 1929: 348.
Lyria.—Cotton and Godfrey, 1932: 51.—Gardner, 1935: 241.—1937: 403.
Lyria (Lyria).—Smith, 1942: 9.
Lyria (Harpeola).—Smith, 1942: 1.
Lyria (Lyria).—Wenz, 1943: 1330.
Lyria (Harpella).—Wenz, 1943: 1331.
Lyria (Sannalyria) Pilsbry and Olsson, 1954: 23 (type species (original designation): *Lyria pulchella* Sowerby).
Lyria (Lyria).— Korobkov, 1955: 313.
Lyria (Harpella).— Korobkov, 1955: 313.
Lyria.—MacPherson and Gabriel, 1962: 217.
Lyria (Paralyria) Shuto, 1962: 69.
Lyria (Lyria).— Weaver and du Pont 1970: 15.
Lyria (Harpeola).— Weaver and du Pont, 1970: 29.
?Lyria (Cordilyria) Bayer, 1971: 204.
Lyria (Lyria).— Hoerle and Vokes, 1978: 106, 107.
Lyria (Harpeola).—Hoerle and Vokes, 1978: 106, 113.

Type species. Original designation: *Voluta nucleus* Lamarck, 1811, Recent, Eastern Australia.

Description. Shell solid, small to medium size, ovately fusiform with sub-conical to gradate spire, occasionally with channeled sutures. Protoconch smooth, variable in size and shape, frequently with impressed sutures, of 1½–3 whorls, the first of which is sometimes deviated at right angles to axis of the shell. Spiral sculpture weakly developed, but usually present on the anterior quarter of the body whorl. Axial sculpture generally well developed and

consisting of strong close set costae, frequently nodulate at the posterior suture. Aperture narrow, elongate, slightly produced anteriorly and reflexed dorsally; outer lip thickened externally rarely denticulate internally; inner lip covered with a thin glaze, occasionally with a small posterior denticle. Columella with two strong anterior plaits and a weaker posterior plait and usually numerous, thin plicae posterior to these, which decrease in size posteriorly. Siphonal notch broad and shallow; fasciole well developed.

Stratigraphic range. Late Cretaceous–Recent.

Distribution. Europe (Paleocene–Miocene), Africa (Senonian (?), Recent), Asia (Senonian (?)–Recent), Australia (Late Oligocene–Recent), New Zealand (Early Miocene), North and Central America (Paleocene–Recent), South America (Late Eocene–Early Miocene).

Comments. Dall (1907) erected *Harpeola* for *Voluta anna* Lesson, separating it from *Lyria* by the presence of a channelled suture and a shallow posterior sinus. These features are variable even within a species and there is every gradation between species with shouldered whorls such as *Lyria quecketti* (Smith), to those with grooved sutures such as *L. nucleus*. As there is no clear cut distinction *Harpeola* is regarded as a synonym of *Lyria*. *Paralyria* was stated to be an intermediate between *Lyria* and *Harpella*, having the rounded whorls and slight shoulder of the former and the high spire of the latter.

Sannalyria was separated from *Lyria* by Pilsbry and Olsson (1954) because of its strongly lirate inner lip, however, species of *Lyria*, e.g. *L. lyraeformis* (Swainson) and *Lyria mitraeformis* (Lamarck), frequently show this feature and its occurrence even varies within a species, so that *Sannalyria* has been relegated to the synonymy of *Lyria*.

Bayer (1971) described *Cordilyria* with *Lyria (Cordilyria) cordis* Bayer as type, and separated it from *Lyria* s.s. on the presence of small denticles between the larger cusps of the radula, which feature is similar to the radula of *Voluta*. The overall shell features of the type species are similar to *Lyria acutiscostata* Pritchard and to some extent *L. deliciosa* (Montrouzier) of the Western Pacific, and it is closely related to *L. beaui* (Fischer and Bernardi) and *L. vegai* Clench and Turner of the Central West Atlantic, so it seems doubtful that this subgenus should be maintained (Emerson, 1985).

The distributional data, though incomplete, suggest that *Lyria* originated during the Late Cretaceous in what is now the south-eastern Asia area of Tethys. It was represented in this area by several species throughout the Tertiary and at the present time there are six or so species in the subtropical and warm temperate Indo-West Pacific area. The genus migrated west into Europe by Paleocene time, where it persisted until the Miocene (*Lyria magorum* Brocchi). It is found in North America in the Paleocene (*Lyria wilcoxiana* Aldrich) and South America in the Late Eocene (*L. sabulosa* Olsson) but became extinct there in the Early Miocene (*L. musicinoides* White). During the late Tertiary the distribution contracted to the Central American region where *Lyria* is represented by six species in the subtropical West Atlantic (Emerson, 1985). The genus migrated south from the Tethys area to the Australian region in the Late Oligocene during the mid Tertiary thermal maximum, and still is represented in the region by three species. In the Early Miocene the range of the genus was temporarily extended to New Zealand, where it was represented by a single species *Lyria zelandica* Finlay.

In the Tertiary rocks of Southern Australia there are seven taxa of which only one, *Lyria mitraeformis crassicostata* sub. sp. nov. is closely related to those still living in the area. Two species are known from the Middle Miocene of north-west Western Australia, one of which is closely related to *L. semiacuticosta* from the Early Miocene of south-eastern Australia. The Australian fossil species show strong affinity with species from the Paleogene of Europe and south-eastern Asia, and with Neogene and living species from the Western Indo-Pacific Region.

Lyria semiacuticostata Pritchard

Plate 1, figure 18
Plate 2, figures 6, 7
Figure 1

Lyria semiacuticostata Pritchard, 1896 : 91, pl. 2, fig. 8.

Description. Shell elongate-ovate with a narrow acute spire and channelled suture. Protoconch small, of 2½ smooth whorls coiled with axis of spire. Spiral sculpture absent. Axial sculpture of thin well-spaced costae present over whole spire, but becoming obsolete on body whorl. Costae tuberculate at posterior suture and decreasing in strength anteriorly on penultimate and body whorls. 20–28 costae present on penultimate whorl. Columella with 3 plaits, numerous posterior ridges and posterior denticle. Siphonal notch and siphonal fasciole well developed.

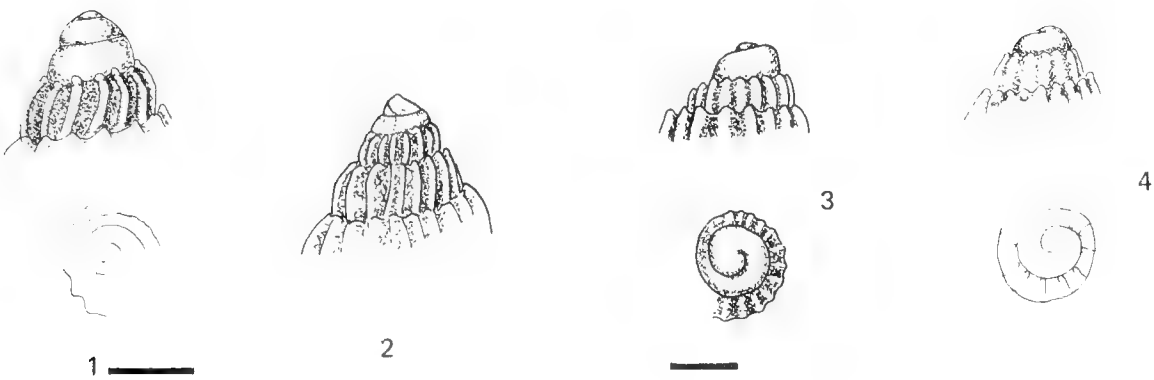

Figure 1. *Lyria semiacuticostata* Pritchard, P2734, hypotype, Lower Bed, Table Cape, Tas. (scale = 1 mm)
Figure 2. *Lyria acuticostulata* sp. nov., P31146, paratype, Fossil Beach.
Figure 3. *Lyria harpularia* Tate, P31877, hypotype, Clifton Bank.
Figure 4. *Lyria gemmata* Tate, P31876, hypotype, Spring Creek, Minhamite. (scale for figs 2–4 = 2 mm)

Dimensions. Holotype (P2653) L29, HA15, W14; Hypotype (P2733) L42, HA24, W19; Hypotype (P2734) L35, HA19, W16.

Location of types. National Museum of Victoria: Holotype P2653, Hypotype P2633, Hypotype P2734, E.D. Atkinson Collection.

Type locality. "Lower bed, Table Cape". FL28, Lower part of cliff between Fossil Bluff and Table Cape, N of Wynyard, Tasmania (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian, Early Miocene.

Occurrence. Type locality; Upper Maude Limestone, Moorabool River near Lethbridge.

Material. Holotype and 4 topotypes.

Comments. The form of the costae of this species has some resemblance to that of *L. gemmata* Tate, but that species has a squatter spire, closer set costae and anterior spiral grooves. *Lyria carolinensis* Kellum, 1926 from the Early Miocene, Silverdale Beds of North Carolina, bears a superficial resemblance to both *L. semiacuticostata* and *L. gemma* (Hoerle and Vokes, 1978).

Three fragmentary silicified specimens from the Trealla Limestone (Middle Miocene "f" stage), east flank of the Cape Range, Geological Survey of Western Australia, locality 30055, (Onslow, 1:250,000 Ref. 185260) are close to typical specimens of *L. semiacuticostata* but the ribs are much thicker, being wider than the interspaces.

The specimen from the Upper Maude Limestone is poorly preserved but appears to belong to this species.

Lyria acuticostulata sp. nov.

Plate 1, figures 2–5
Figure 2

Lyria acuticostata Chapman, 1922: 15, pl. 3, fig. 23 (non Chapman, 1920).

Description. Shell ovate, with low or even squat spire, and tumid body whorl abruptly contracted to canal. Protoconch of 1 ½ whorls, the first of which deviated at right angles to axis of spire and granulated, flattened and irregular; second whorl smooth shining and convex. Spire whorls convex with impressed suture. Spiral sculpture of faint striae covering the whole shell but often absent. Axial sculpture of thin, erect, flexuous costae which extend from suture to suture on spire, and from suture to fasciole on body whorl, 19–29 costae present on last whorl. Interspaces between costae wide. Columella with 2 prominent anterior plaits, a weaker plait posterior to these and 3–4 weak posterior ridges. Canal twisted and reflexed dorsally, siphonal notch shallow, siphonal fasciole prominent.

Dimensions. Holotype (P31145) L18, HA11, W9; Paratype (P31146) L18, HA10, W9; Paratype (P31147) L19, HA12, W9; (P31148) L21, HA12, W9;

Location of types. National Museum of Victoria: Holotype P31145, Paratype P31146, Paratype P31147, presented J. Cunningham 17 Oct 1966. Hypotype (Chapman, 1922, pl. 15, fig. 23) P13249.

Type locality. FL78, Shore platform, Fossil Beach, Balcombe Bay, 3 km S of Mornington (Western Port 273658). Balcombe Clay, Balcombian, Middle Miocene.

Stratigraphic range. Batefordian, Early Miocene–Bairnsdalian, Middle Miocene.

Occurrence. Type locality; FL38, Curlewis; FL40, Belmont Shaft; FL 48, Boornong Road Cutting; FL67, SE end of Gibson Beach; FL69, Red Hill, Shelford; FL77, Altona Coal Shaft; FL81, Overburden, Batesford Quarry; FL 82, Clifton Bank, Muddy Creek; FL100, Murgheboluc 4A; FL103, Lower and Middle beds, downstream Gunyoung Cr; FL104, Manyung Rocks.

Material. Types and 30 topotypes.

Comments. This species is distinguished from *L. acuticostata* by the presence of continuous thin erect costae, and by the convex spire whorls. The Torquay specimen figured by Chapman (1922, pl. 3, fig. 22, P13248) is unique, and differs somewhat from this species, though it is obviously ancestral. Of living species it most resembles the type of the genus, *L. nucleus*, but that species has wider and closer spaced costae and more tumid whorls. *L. harpularia* (Lamarck) Lutetian, Paris Basin has fewer and stronger ribs and a prominently thickened outer lip. *L. varicosa* Vredenburg, Oligocene, Burma, has broader ribs and appears closely related to the Torquay specimen.

Batesfordian and Bairnsdalian specimens generally are squatter and more tumid than Balcombian specimens, but still fall within the range of variation of the latter.

Lyria harpularia Tate

Plate 1, figures 7, 12, 17, 19, 20
Figure 3

Lyria harpularia Tate, 1888: 176, pl. 12, fig. 12 (figure only).—Tate, 1889: 118 (description).—Harris, 1897: 99, pl. 4, figs 9a, b.—Cotton, 1949: pl. 14.

Description. Shell ovate, rather tumid with low gradate spire. Protoconch of 1½ smooth whorls with impressed sutures, coiled with axis of shell and markedly differentiated from teleconch whorls. Sculpture of numerous thin, erect, flexuous costae, terminated posteriorly in blunt points and separated from posterior suture by narrow channel. Spiral sculpture of fine threads feebly developed on, or absent from, spire and usually present on anterior quarter of body whorl. Body whorl rather tumid and abruptly contracted anteriorly. Aperture elliptical. Columella with 2 strong anterior plaits, one weak plait posterior to these and with several other thin plaits or folds on posterior portion of columella. Siphonal notch deep; siphonal fasciole well developed.

Dimensions. Holotype (T395A) L33, HA19, W17; Hypotype (P31150) L40, HA24, W21; Hypotype (P31877) L30, HA17, W14; Hypotype (P31878) L35, HA20, W17.

Location of types. South Australian Museum: Holotype T395A, R. Tate Collection. National Museum of Victoria: Hypotypes P31150, F.S. Colliver Collection; P31877, G.B. Pritchard Collection; P31878, F.A. Cudmore Collection.

Type locality. Muddy Creek, i.e. FL82, Clifton Bank, Muddy Creek, 5 miles W of Hamilton (Coleraine WD825219). Muddy Creek Formation, Balcombian.

There is some doubt as to the correct type locality, as the preservation of the holotype, T395A, figured by Tate in 1888 and described in 1889, is typical of Schnapper Point (i.e. Balcombe Bay) and not Muddy Creek, which is the locality cited in the explanation of the figure. Schnapper Point is written on the tablet on which the type is glued, together with Muddy Creek and Gellibrand River, but there is no clear indication which specimen comes from Schnapper Point.

Stratigraphic range. Batesfordian (?), Balcombian, Middle Miocene.

Occurrence. FL38, Curlewis; FL69, Red Hill; FL70, Farrells; FL 77, Altona Bay Coal Shaft; FL78, Fossil Beach; FL80, Moorabool River; FL81, Batesford Quarry; FL82 Type Locality.

Material. Holotype and 20 topotypes.

Comments. The record from FL38, Curlewis is based on a single specimen and may possibly have an inaccurate label, as the species is not represented in any other localities of similar age. Matrix from this specimen suggests it may come from FL69, Red Hill. This species has some resemblance to *L. anna* (Lesson) but the latter is more elongate with coarser and fewer costae and has a more prominent channel, in fact almost a shoulder, against the suture. *L. turgidula* (Deshayes) Lutetian, Paris Basin is of similar morphology but also has fewer and coarser costae.

Lyria acuticostata Chapman

Plate 2, figures 8, 13

Lyria acuticostata Chapman, 1920: 24.

Description. Shell elongate with flat whorls and thick axial costae. On body whorl costae are 2 mm thick and interspaces 1.5 mm wide.

Dimensions. The length of a complete shell would be about 35 mm.

Location of types. National Museum of Victoria: Syntypes P13164, P13165, F.A. Cudmore Collection. The latter should be chosen as lectotype if it is ever necessary to choose such.

Type locality. Ooldea well, Ooldea Station, Transcontinental Railway, South Australia. Nullabor Limestone, Middle (?) Miocene.

Stratigraphic range. Middle (?) Miocene.

Occurrence. Type locality only.

Comments. The available material of this species consists of the two external moulds upon which Chapman founded the species. They are fragments of two individuals so comparison with other species is difficult. It is not related to the delicately costated *L. acuticostulata* sp. nov. of the Victorian Miocene, with which Chapman allied it, but more to the coarse ribbed southern Australian living species, *Lyria mitraeformis*, from which it differs by the flatter whorls and more elongate spire. It is very close to *Lyria mitraeformis crassicostata* subsp. nov. from the Roe Calcarenite, but has less swollen whorls and the suture is not as impressed.

Lyria sp.

Occurrence. Geological Survey of Western Australia locality 30055, E flank Cape Range (Onslow, 1:250,000 185260). Trealla Limestone, Middle Miocene "f" stage.

Remarks. Two poorly preserved specimens are available. The species is rather squat with swollen whorls, somewhat impressed sutures and prominent thick axial costae as wide as the interspaces and with fine, close set lirae covering the whole of the whorls. In overall shape it resembles *Lyria mitraeformis mitraeformis*, but has coarser ribs and is covered with fine lirae, a feature which sets it apart from most species known to the writer, however it does resemble a specimen from the Miocene of Java illustrated by Martin (1916, pl. 1, fig. 20) as *Lyria edwardsi* d'Archaic (= *Lyria jugosa* Sowerby). *Lyria jugosa* has a prominenty channeled suture, but some specimens do have whorls entirely covered in lirae.

Lyria gemmata Tate

Plate 1, figures 6, 13, 14
Figure 4

Lyria gemmata Tate, 1889b: 118, pl. 3, fig. 4.

Description. Shell ovate with subconical spire and slightly channelled suture. Protoconch of 1½ smooth whorls coiled with axis of shell. Spiral sculpture of fine, well spaced grooves on anterior half of body whorl. Axial sculpture of closely spaced, slightly flexuous costae, which terminate on posterior suture with a small tubercle and decrease in strength anteriorly on body whorl; 25–30 costae present on body whorl. Columella with 2 strong anterior plaits, a weaker posterior plait and several weak folds posterior to these. Outer lip of aperture thickened. Canal reflexed dorsally. Siphonal notch weak; siphonal fasciole well developed.

Dimensions. Holotype (T613) L19, HA–, W9; Hypotype FL132 (P31876) L25, HA15, W13.

Location of types. South Australian Museum: Holotype T613, R. Tate Collection. National Museum of Victoria: Hypotype P31876, coll. E.D. Gill and H.E. Wilkinson, 16 May 1962.

Type locality. Upper beds, Muddy Creek, i.e. FL139, McDonalds bank, Muddy Creek below Yulecart Hall (Coleraine 827219). Grange Burn Formation, Kalimnan, Early Pliocene.

Stratigraphic range. Cheltenhamian, Late Miocene–Kalimnan, Early Pliocene.

Occurrence. Type locality; FL132, Spring Creek, Minhamite.

Material. Holotype, 1 topotype P31149 and 2 specimens from Minhamite.

Comments. The resemblance of this species to *L. semiacuticostata* has already been mentioned and its resemblance to *L. gracilicostata* is dealt with under that species.

Lyria gracilicostata Ludbrook

Plate 28, figures 1–6

Lyria gracilicostata Ludbrook, 1978: 163, pl. 18, figs 15–18.

Description. Shell elongate-ovate with narrow subacute spire and impressed suture. Protoconch of 1½ smooth whorls, coiled with axis of shell. Spiral sculpture of several low broad lirae confined to anterior quarter of last whorl. Axial sculpture of strong close-set costae, 29–34 on body whorl, which are interrupted close to posterior suture so that they are nodulate against it. Columella with 2 prominent anterior plaits and numerous posterior ridges. Posterior denticle rarely present. Outer lip of aperture thickened internally and externally.

Dimensions. Holotype (GSWA F6951) L43, HA25, W19; Hypotype (P56031) L45, HA23, W20; Hypotype (P56032) L35, HA20, W15.

Location of types. Geological Survey of Western Australia: Holotype F6951, Paratype F6951, coll; D.C. Lowry. Western Australian Museum: Paratypes WAM 69.511, 66.621, 69.510, 69.561, 70.32, 70.33. Geological Survey of South Australia: M1270, M3251, National Museum of Victoria: Hypotypes P56031 P56032, coll. V. Ryland, G.W. and W.E. Kendrick, 5–13 Aug. 1978.

Type locality. Locality 4133-FL7, 21 km NE of Eyre (Burnabbie 443032), (32°05′08″S, 126°24′30″E).

Occurrence. Roe Calcarenite, various borrowpits along the Eyre Highway and foundation holes for Hampton Microwave Tower, Roe Plain, Western Australia.PL 3173, Point Ellen, South Australia.

Material. Holotype and 26 specimens.

Comments. This taxon is closely related to *L. gemmata*, but is more elongate and has a higher spire. It may fall within the range of variation of the latter if more material of that species was available. Certainly *L. gemmata* is ancestral to this taxon. *L. delessertiana* (Petit de Saussaye) of Madagascar seems to be the closest relative among living species of the genus. *Lyria ickei* Martin from the Late Miocene of Java also bears a close resemblance but it is much smaller with a very low spire.

Lyria mitraeformis crassicostata subsp. nov.

Plate 28, figures 7–12

Lyria mitraeformis.—Ludbrook, 1978: 164, pl. 18, figs 13, 14.

Description. Shell elongate, fusiform with high spire of somewhat rounded whorls and with small shoulder developed on body whorl. Protoconch of 1½ smooth whorls, first of which deviated at low angle from axis of shell. Spiral sculpture of low broad lirae, present on anterior quarter of body whorl. Axial sculpture of coarse well spaced costae, 14–17 on body whorl. Surface of outer lip of aperture thickened exteriorly. Columella with 3 well developed anterior plaits, several posterior ridges and posterior denticle.

Dimensions. Holotype (WAM 79.396a) L58, HA29, W23; Paratype (WAM 79.404b) L38, HA22, W17; Paratype (P56034) L39, HA19, W17.

Location of types. Western Australian Museum: Holotype WAM 79.396a, coll. V.A. Ryland, G.W. and W.E. Kendrick, 5–13 Aug 1978; Paratype WAM 79.404b, coll. V.A. Ryland, G.W. and W.E. Kendrick, 22–28 Sep 1976. National Museum of Victoria: Paratype P56034, coll. T.A. Darragh, 7 Sep 1973.

Type locality. Quarry on access road to Hampton Microwave Repeater Tower. 1.5 km N of Tower, Roe Plain, Western Australia (Eucla, 1:250,000 563047). Roe Calcarenite.

Stratigraphic range. Roe Calcarenite.

Occurrence. Roe Calcarenite, various borrow pits along Eyre Highway and foundation holes for Hampton Microwave Tower, Roe Plain, Western Australia.

Material. Types, 21 topotypes and 19 other specimens.

Comments. This taxon is ancestral to the living *L. mitraeformis* and differs from typical specimens of *L. mitraeformis* by its higher spire, more prominent shoulder and fewer and more widely spaced axial costae. The affinity with *L. acuticostata* has been mentioned above, and it is probably derived from it. In morphology it is intermediate between *L. acuticostata* and *L. mitraeformis mitraeformis*.

Lyria mitraeformis mitraeformis (Lamarck)

Plate 2, figure 1

Voluta mitraeformis Lamarck, 1811: 73.—1822: 347.
Voluta multicostata Broderip, 1827: 82, pl. 3, fig. 2.
Voluta mitraeformis.—Kiener, 1839: 36, pl. 41, fig. 2.—Kuster, 1840: 178, pl.38, fig. 2.
Voluta mitriformis (sic).—G.B. Sowerby II, 1845: 216, pl. 52, figs 81, 82; pl. 55, fig. 109.
Voluta mitraeformis.—Reeve, 1849: No. 7, pl. 3, fig. 7a, b.
Lyria mitraeformis.—Tryon, 1882: 103, pl. 31, fig. 143.
Voluta (Lyria) grangeri G.B. Sowerby III, 1900: 440, pl. 11, fig. 2.
Lyria multicostata.—Cotton and Godfrey, 1932: 51, pl.2, fig. 12.
Lyria kimberi Cotton, 1932: 538, figs 1–3.
Lyria multicostata.—Smith, 1942: 11, fig. 17.
Lyria kimberi.—Cotton, 1957: fig. 1.
Lyria mitraeformis.—Cotton, 1957: fig. 2.—MacPherson and Gabriel, 1962: 217, fig. 258.
Lyria (Lyria) grangeri.—Weaver and du Pont, 1968: 36, pl.3, figs 1–6.
Lyria (Lyria) kimberi.—Weaver and du Pont, 1970: 21, pl. 4 K, L.
Lyria (Lyria) mitraeformis.—Weaver and du Pont, 1970: 22, pl. 5C–E; pl. 6A, B.
Lyria mitraeformis.—Wilson and Gillett, 1971: 126, pl. 83, figs 7, 7a, b.

Description. Shell fusiform, of medium to large size, with rounded costate whorls and impressed sutures. Protoconch of 1½ smooth whorls, first of which deviated about 45° to axis of shell. Teleconch whorls convex, impressed at suture and bearing strong axial costae as thick as interspaces; costae number 17 to 20 on body whorl. Spiral sculpture of low broad, somewhat irregularly spaced costae on anterior quarter of body whorl only. Surface of outer lip of aperture thickened exteriorly. Columella with 2–3 strong anterior plaits and numerous posterior ridges.

Dimensions. SAM (D10185), L30, HA17, W14.

Location of types. Muséum d'Histoire Naturelle, Geneva: syntype 1103.38.2. South Australian Museum. Holotype of *Lyria kimberi* Cotton D10185.

Type locality. "Côtes de Java (Laichenau), et celles de la Nouvelle-Hollande (Péron)." It is probable that the syntype figured by Kiener was collected by Péron in Bass Strait or South Australia.

Stratigraphic range. Pleistocene–Recent.

Occurrence. Fossil: Western Australia: Adrians Nursery Bore cnr Thomas and Semple Rds, Jandacot at 126–129 ft, Frank Paulicks Bore, W side of Semple Rd, Jandacot at 130 ft. Living: Cape Leeuwin, South-west Western Aus-

tralia-Gippsland, Victoria; Northern Tasmania.

Comments. The writer agrees with previous authors who have placed *L. multicostata* and *L. grangeri* in the synonymy of *L. mitraeformis* and also places *L. kimberi* therein. The type specimen of the latter is merely a rather squat specimen from Port Lincoln but all grades between this and typical specimens of *L. mitraeformis* can be found in the same area. The colour differences cited by Weaver and du Pont probably have arisen because the holotype was collected as a dead shell.

Lyria nucleus (Lamarck)

Voluta nucleus Lamarck, 1811: 73.
Lyria (Lyria) nucleus.—Weaver and du Pont, 1970: 23, pl. 5 F–H.

Comments. This species occurs off northern New South Wales, Norfolk Island and Kermadec Islands, New Zealand. Weaver and du Pont (1970) listed five synonyms of this species and have provided a good description and figures.

Lyria deliciosa (Montrouzier)

Voluta deliciosa Montrouzier, 1859: 375.
Lyria deliciosa howensis Iredale, 1937: 129.
Lyria (Lyria) deliciosa howensis.—Weaver and du Pont, 1970: 18, pl. 4E.

Comments. This species occurs from central Queensland to northern New South Wales, Lord Howe Island and New Caledonia. Some authors have considered that the Australian populations should be subspecifically separated from the New Caledonian population as indicated above.

Lyreneta Iredale, 1937

Lyreneta Iredale, 1937: 128.
Lyria (Lyreneta).—Weaver and du Pont, 1970: 28.

Type species. Original designation: *Lyreneta laseroni* Iredale, 1937 (= *Voluta (Callipara) brazieri* Cox, 1873 non Brazier, 1870); Wooli Wooli, northern New South Wales.

Comments. This genus is monotypic and the type species is rare. As yet it has not been found as a fossil. The type species ranges from central to northern New South Wales. The early teleoconch whorls bear a typical *Lyria* type sculpture but these are almost enveloped in the body whorl which bears no sculpture. The plaits on the columella are typical of species of *Lyria*. The overall appearance bears a close resemblance to that of *Callipara bullatiana* Weaver and du Pont from South Africa.

Leptoscapha Fischer, 1883

Voluta (Leptoscapha) Fischer, 1883: 608.
Voluta (Leptoscapha).—Cossmann, 1899: 191.
Leptoscapha.—Cossmann, 1889: 120.—Wenz, 1943: 1340.

Type species. Original designation: *Voluta variculosa* Lamarck, 1803; Eocene, Grignon, France.

Description. Shell small, ovately fusiform. Protoconch of 1–1½ smooth shining whorls, first of which deviated to axis of shell. Spiral sculpture of numerous close set threads. Axial sculpture absent except for trace of apertural varices. Aperture lenticular, elongate, produced anteriorly to form short canal which is reflexed dorsally. Outer lip thickened externally and on some species internally, constricting anterior canal, and also occasionally with posterior denticle on inner surface. Inner lip covered with thick glaze of callus. Columella with 3 strong anterior plaits, of which anterior is weakest, and 1 or 2 other weak posterior plaits. Siphonal notch shallow; siphonal fasciole well developed.

Stratigraphic range. Middle Eocene–Middle Miocene, Recent.

Distribution. Europe (Middle–Late Eocene), South-east Asia (Late Eocene), South-eastern Australia (Middle Miocene, Recent).

Comments. This genus is characterised by its small size, being amongst the smallest of the volutes, by its fusiform shape and absence of axial sculpture, except for the trace of apertural varices, a feature which is most uncommon in the family. The genus to which it seems to be most closely related is *Mitreola.*

In addition to the type species the following species seem to belong in the genus: *Voluta mitreola* Lamarck, Lutetian, Paris Basin; *V. intusdentata* Cossmann, Bartonian, Paris Basin; *V. pusilla* Martin, Late Eocene, Java; *V. crassilabrum* Tate, Middle Miocene, Recent, Australia. Specimens of all these species are rare and as a consequence little is known of the stratigraphical history or distribution of the genus.

Leptoscapha crassilabrum (Tate)

Plate 1, figures 1, 8, 9
Plate 27, figures 2, 3, 5–10

Voluta crassilabrum Tate, 1889b: 128, pl. 3, figs 2a–c.
Ericusa crassilabrum.—Cotton, 1949: pl. 15.

Description. Shell thick, small, ovate. Protoconch

of 1½ smooth, shining rounded whorls, first of which slightly deviated from axis of shell. Teleconch whorls convex. Body whorl convex and rather abruptly contracted anteriorly. Spiral sculpture of thin close set wavy threads over whole of whorls. Axial sculpture weak and irregular, consisting of trace of previous apertural varices. Aperture elongate ovate, narrow and produced anteriorly into short dorsally reflexed canal. Outer lip thickened externally and internally, occasionally bearing small posterior denticle. Inner lip covered with thick callus. Columella usually with 3 anterior plaits and 1 or 2 weaker posterior plaits. Siphonal notch absent; siphonal fasciole prominent.

Dimensions. Holotype (T622A) L9, HA-, W4, Hypotype (P32207) L15, HA10, W7; (F53231) L8, HA4.5, W3.5; (F53232) L11, HA6, W4.5; (F53233) L12, HA6, W5; (F53234) L8.5, HA4.5, W4.

Location of types. South Australian Museum: Holotype T622A. National Museum of Victoria: Hypotype P32207, F.A. Cudmore Colln. Hypotypes F53231-4, coll. M.P. Marrow, 28 Dec 1983.

Type locality. Lower beds, Muddy Creek, i.e. FL82, Clifton Bank, Muddy Creek, 8 km W of Hamilton (Coleraine WD825219). Muddy Creek Formation, Balcombian.

Stratigraphic range. Balcombian-Bairnsdalian, Middle Miocene, Recent.

Occurrence. Type locality; FL103, Gunyoung Creek; FL104, Manyung Rock; Shell sand, Gleesons Landing, Daly Head, Yorke Peninsula, South Australia.

Material. Holotype, 1 topotype and 5 other fossil specimens and 11 recent specimens.

Comments. Tate (1898:387) has pointed out the close similarity between this species and *L. variculosa*. The sculpture, aperture and plaits are exactly the same as this species, however *L. variculosa* is more elongate and the protoconch is deviated almost at right angles to the axis of the shell. In shape *L. crassilabrum* is closely simliar to *L. mitreola and L. pusilla*.

The recent specimens were collected from shell sand and some are, therefore, somewhat rolled and abraded, but the sculpture, size and shape match the fossil specimens closely. Three of the specimens are sufficiently well preserved to show a colour pattern of white tentlike triangular markings on an orange base, somewhat similar to that of *Amoria praetexta* (Reeve) and *Notovoluta verconis* (Tate).

The occurrence of this species in the living fauna has a parallel with that of *Notopeplum translucidum* Verco, which is found in Early and Middle Miocene strata and living and with *Notovoluta pseudolirata* (Tate) which is found in Middle Miocene strata and living.

The distribution of the known species suggests that the genus may have been widespread through the Tethys area in the Eocene and migrated into the Southern Australian region in the Miocene, when a number of other Tethyan genera also made their appearance there (Darragh, 1985).

Mitreola Swainson, 1833

Mitreola Swainson, 1833: pl 128.
Lyria (Enaeta) Adams and Adams, 1853: 167. (Type species, subsequent designation, Cossmann, 1899): *Voluta harpa* Barnes, 1824 = *V. barnesii* Gray, 1825).
Strigatella (Mitreola). – Adams and Adams, 1853: 174.
Lyria (Enaeta). – Adams and Adams, 1858: 618.
Voluta (Enaeta). Chenu, 1859: 190.
Mitra (Mitreola). – Chenu, 1859: 194.
Lyria (Enaeta). – Tryon, 1882: 104.
Enaeta. – Fischer, 1884: 610.
Mitra (Mitreola). – Fischer, 1884: 612.
Enaeta. – Cossmann, 1899: 105.
Mitreola. – Cossmann, 1899: 159.
Enaeta. – Dall, 1907: 351.
Lyria (Enaeta). – Thiele, 1929: 348.
Enaeta. – Smith, 1942: 12.
Strigatella (Mitreola). – Wenz, 1943: 1330
Lyria (Enaeta). – Wenz, 1943: 1331. – Korobkov, 1955: 314.
Mitreola. – Korobkov, 1955: 320.
Lyria (Enaeta). – Keen, 1958: 432.
Lyria (Enaeta). – Weaver and du Pont, 1970: 25.
Mitreola. – Cernohorsky, 1970: 62.
Lyria (Enaeta). – Keen, 1971: 619.
Lyria (Enaeta). – Cate, 1972: 47.
Enaeta. – Abbott, 1974: 245.
Lyria (Enaeta). – Hoerle and Vokes, 1978: 106, 114.

Type species. Subsequent designation. (Herrmannsen, 1847): *Mitra monodonta* Lamarck, 1803; Eocene, Grignon, France.

Description. Shell of small size, solid, ovately-fusiform, frequently with shouldered whorls. Protoconch of 1-1½ smooth whorls, first of which is very slightly deviated from axis of shell. Axial sculpture of coarse to fine ribs, sometimes absent from body whorl. Spiral sculpture weak or absent. Aperture lenticular, elongate, slightly notched posteriorly and produced anteriorly to form short canal, which is frequently reflexed dorsally. Outer lip thickened externally and bearing internally a denticle situated slightly to posterior of midpoint; occasionally with serrations on anterior half. Inner lip covered with thick glaze of callus. Columella with 3 or 4 strong anterior plaits and often with weak posterior plaits. Siphonal notch and siphonal fasciole present, variably developed.

Stratigraphic range. Paleocene–Recent.

Distribution. Europe (Paleocene–Oligocene). South-eastern North America, Central America, Northern South America (Early Miocene–Recent), South-west Australia (Late Eocene).

Comments. Shells of this genus are amongst the smallest in the family. Both Cernohorsky (1970) and Cate (1972) have demonstrated the similarity between *Mitreola* and *Enaeta* and the latter author cites the following differences between them: presence of labral nodule on the outer lip of *Enaeta,* lack of prominent parietal wall in *Enaeta,* the more slender shell of *Mitreola,* the more prominent and more mamillate nucleus in *Mitreola* and differences in colour pattern between some species of the genera. A comparison between specimens of *Enaeta cumingi* (Broderib) and *Mitreola raricostata* (Lamarck) shows that they are alike and that most of the alleged differences are not consistent. The labral nodule is present in most, if not all, species of *Mitreola* as already indicated by Cernhorsky (1970) and the other differences cited are characters which frequently vary greatly within particular species of Volutidae and are not regarded as being of generic significance. The writer regards *Enaeta* as a junior synonym of *Mitreola.*

Mitreola was established in Europe in the Paleocene, where it remained through to the Oligocene. It apparently migrated west and appeared in the Central American region in the Early Miocene and has remained in this area to the present. Living species are confined to the subtropical Central American region. The genus is also known from a single species in the Late Eocene of South-western Australia and represents an example of the Tethyan Indo-Pacific element in the Australian Eocene (Darragh, 1985).

Mitreola salaputium sp. nov.

Plate 1, figures 10,-11, 15, 16

Description. Shell very small, ovately fusiform. Protoconch of 1 ½ smooth whorls, first of which very slightly deviated from axis of shell. Teleconch whorls slightly depressed at posterior suture then slightly convex. Body whorl convex and abruptly contracted anteriorly. Axial sculpture of thick, low costae, as wide as interspaces, present on first teleconch whorl and subsequent spire whorls, but absent from body whorl. Spiral sculpture absent. Aperture narrow, elongate-ovate, notched posteriorly and slightly produced anteriorly into short canal. Outer lip of aperture thickened externally into prominent varix and internally bearing a small denticle slightly posterior to midpoint. Inner lip covered with thick callus. Columella with 4 prominent plaits and posterior denticle. Siphonal notch weak, siphonal fasciole weakly developed.

Dimensions. Holotype (WAM 79.386) L11, HA5, W4.5; Paratype (P50007) L10.5, HA5, W4.

Location of types. Western Australian Museum: Holotype WAM 79.386. National Museum o Victoria: Paratype P50007 coll. T.A. Darragh and G.W. Kendrick, 30 Aug 1973.

Type locality. Gravel scrape, Thompsons Rd, 1.9 km N of Mount Franklin Road, 24 km N of Walpole, Western Australia (Deep River, 1:50,000 743487). Pallinup Formation, Late Eocene.

Stratigraphic range. Late Eocene.

Material. Types and 7 topotypes.

Comments. This species is the smallest of the Australian volutes. In overall size, shape and sculpture, it most closely resembles the living *Mitreola reevei* (Dall) from Honduras. It differs from that species by the presence of four well developed plaits rather than the many weak plaits of the former, by its weak rather than strong siphonal notch and by the very weak posterior sutural depression which is quite prominent in *M. reevei.* It differs from *Leptoscapha crassilabrum,* its closest Australian relative, by the presence of well developed axial costae.

Scaphellinae H. and A. Adams, 1858

(= Haliinae Thiele, 1929; Auriniinae Smith, 1942)

Diagnosis. Head broad, flat, bilobed with tentacles merely extensions of the lobes. Siphon with single left appendage. Operculum absent. Tubular salivary gland of anterior digestive system short and free from racemose salivary gland. Gland of Leiblein large and convoluted, surrounding and bound to oesophagus. Radula uniserial, with Y-shaped usually tricuspid rachidian, central cusp of which concave and well developed and lateral cusps reduced to denticles or occasionally absent. Protoconch of about 2 whorls somewhat irregular with callused summit, sometimes with exsert tip (calcarella).

Remarks. The above diagnosis is based on an anatomical description by Clench and Turner (1964). As recognised here the subfamily excludes *Amoria* and related taxa for reasons which are stated under Amoriinae. *Notopeplum* and *Notovoluta* which were included in the subfamily by Weaver and du Pont (1970) have also been excluded on the basis of their anatomy which is discussed under the respective genera.

The cleft head of species of the Scaphellinae is reminiscent of species in Athletinae and Volutinae. The early appearance of the Scaphellinae in the stratigraphic record reflects this relationship since all three subfamilies are known from the earliest Tertiary. The earliest undoubted representatives of the Scaphellinae appear in the Paleocene of Europe and North America. There is a single species of *Scaphella (Aurinia)* known from the Late Eocene of Victoria, the only record of the subfamily in the Australian Tertiary.

The genera included in the subfamily are as follows:

Scaphella Swainson, 1832.
S. (Clenchina) Pilsbry and Olsson, 1953.
S. (Aurinia) H. and A. Adams, 1853.
Ampulla Roding, 1798 (= *Halia* Risso, 1826).
Volutifusus Conrad, 1863.
Atraktus Gardner, 1937.
Caricella Conrad, 1855.
Montia Glibert, 1973.
M. (Houzeauia) Glibert, 1973.
?Sycospira Palmer, 1953.

Scaphella Swainson, 1832

Scaphella (Aurinia) H. and A. Adams, 1853.

Fulgurararia (Aurinia) H. and A. Adams, 1853: 166.
Voluta (Aurinia). – Crosse, 1871: 309. – Fischer, 1883: 608.
Scaphella (Aurinia). – Dall, 1889: 150. – Dall, 1890: 80.
Aurinia. – Koenan, 1890: 522. – Cossmann, 1899: 128.
Scaphella (Aurinia). – Thiele, 1929: 350.
Aurinia. – Smith, 1942: 63 (in part).
Scaphella (Aurinia). – Wenz, 1943: 1352.
Rehderia Clench, 1946: 45 (Type species (original designation): *Aurinia schmitti* Bartsch).
Scaphella (Aurinia). – Clench, 1946: 51.
Aurinia. – Gardner, 1948: 261.
Auriniopsis Clench, 1953: 378 (Type species (original designation: *Scaphella kieneri* Clench).
Aurinia. – Pilsbry and Olsson, 1953: 5.
Scaphella (Aurinia). – Weaver and du Pont, 1970: 144.

Type species. Monotypy: *Voluta dubia* Broderip, 1827; Recent, south-eastern United States of America.

Description. Shell thin, elongate, fusiform. Protoconch of 1½–2 smooth whorls somewhat truncate, first somewhat irregular and often with prominent pointed calcarella. Whorls occasionally with weak shoulder. Sculpture absent, or if present weakly developed and consisting of weak axial costae on spire whorls and fine spiral threads. Columella margin straight or weakly sigmoidal and bearing 2 or 3 weak plaits which may be absent on adult specimens. Siphonal notch and fasciole absent.

Stratigraphic range. Paleocene–Recent.

Distribution. Europe (Paleocene–Pliocene); North America (Miocene–Recent); South-eastern Australia (Victoria) (Late Eocene).

Comments. This subgenus is distinguished from *Scaphella* s. s. by the absence of any trace of siphonal fasciole, by the reduced number or even absence of plaits and by the tricuspid rather unicuspid radula. The taxon first makes its appearance in the Danian of Denmark and various species occur scattered through the stratigraphic column in England, Germany, Holland, Belgium and France. In the Paleogene the taxon is confined to Northern Europe and does not occur in the south until the Miocene. It became extinct in Europe in the Late Pliocene. In the Middle Miocene it first appears in the South-eastern United states and various species occur there and in Central America through the late Tertiary to the present. There is a single species in the Late Eocene of Victoria, Australia, closely related to Eocene and Oligocene species of Europe and represents another example of the Tethyan Indo-Pacific element in the australian Eocene.

Scaphella (Aurinia) johannae sp. nov.

Plate, 2, figures 9–12
Figure 5

Description. Shell fusiform with gently tapering spire. Protoconch conical, of 1½ smooth, flattened and slightly irregular whorls with impressed sutures and coiled with axis of shell. Teleoconch whorls smooth and regularly convex. Body whorl rather abruptly contracted anteriorly and produced into short canal. Columella with 1 strong anterior plait and 3 or 4 feeble posterior plaits. Siphonal notch and fasciole absent.

Dimensions. Holotype (P41757) L47, HA27, W18; Paratype, immature (P41758) L34, HA21, W13.

Location of types. National Museum of Victoria: Holotype P41757 coll. T.A. Darragh 24 Feb 1971; Paratype P41758 coll. T.A. Darragh 18 Oct 1971.

Type locality. FL11, 9.6 m dark clay beneath greensand, washout nearest Browns Creek, Johanna (Glenaire 080057). Browns Creek Clay, Aldingan, Late Eocene.

Stratigraphic range. Aldingan, Late Eocene.

Occurrence. Type locality only.

Material. Types and 3 topotypes.

Comments. In shape this taxon resembles *Scaphella*

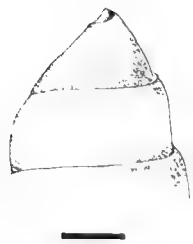

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Figure 5. *Scaphella (Aurinia) johannae* sp. nov., P41757, holotype, Browns Creek. (scale = 2 mm)

(Aurinia) crenistriata (von Koenan) from the Paleocene of Copenhagen and *S. (A) bolli* (Koch) from the Middle Miocene of Germany and Belgium but those species have numerous spiral threads present over the whole of the spire whorls. *Scaphella (A.) weatherellii* (Sowerby) from the Early Eocene of England is more elongate and the whorls are depressed at the posterior suture. *Scaphella (A.) siemsseni* (Boll) from the Middle and Late Oligocene of the North Sea basin is very close in general appearance, but is more elongate with a narrower more elongate spire.

Subfamily uncertain

Notovoluta Cotton, 1946

Notovoluta Cotton, 1946: 15.—Weaver and du Pont, 1970: 167.—Wilson, 1972: 347.

Type species. Original designation: *Voluta kreuslerae* Angas, 1865; Recent, South Australia.

Description. Shell moderately thick fusiform, elongate to elongate-ovate. Spire subconical or gradate with prominantly shouldered whorls. Protoconch of 2 or 3 smooth usually dome-shaped whorls with central nucleus and coiled with axis of shell. Spiral sculpture if present of fine threads. Axial sculpture of plicae or strong costae but often reduced to tubercles or even absent. Thin axial plicae usually present on first and 2nd teleoconch whorls. Aperture elongately eliptical; anterior portion of outer lip slightly reflexed dorsally; columella usually with 4 strong plaits and rarely 1 or 2 weaker plaits. Canal slightly reflexed dorsally; siphonal notch shallow and wide; siphonal fasciole moderately developed.

Stratigraphic range. Late Eocene–Recent.

Distribution. Southern Australia. Victoria (Late Eocene–Middle Miocene); South australia (Middle Miocene–Late Pliocene, Recent); Western Australia, south coast (Early Pleistocene–Recent), midwest coast (Recent).

Comments. The dome shaped protoconch and fine plicae on the first and second spire whorls are the most characteristic features of the genus. Cotton erected the genus to include the type species, *N. occidua* Cotton, *Voluta rossiteri* Brazier, and *V. verconis* Tate. Subsequently (Cotton, 1947) he placed *Voluta thatcheri* McCoy and *V. perplicata* Hedley and ten fossil species in the genus. Weaver and du Pont (1970) removed the latter two living species to the genus *Cymbiolacca* and were followed by Wilson (1972). Examination of the anatomy of *V. thatcheri* and *V. perplicata* by the writer confirms this action. Of the fossil species listed by Cotton, only *V. cathedralis* Tate, *V. tabulata* Tate, *V. lintea* Tate and *V. sexuaplicata* Chapman (= *V. ellipsoidea* Tate) have features in common with the living species and are retained by the writer in the genus. the others are placed in *Alcithoe.*

The fossil species of the genus fall into two groups, one characterised by the type species *Voluta kreuslerae,* to which also belong all the other living species, and the other characterised by *V. saginata* Finlay. The latter group has fusiform shells and lacks the prominent shoulders typical of the first group, but the protoconchs and apertural features are similar and larger specimens often have poorly developed shoulders. It is possible that this latter group is related to the group of *Nannamoria ralphi* Finlay, but because of the presence of axial riblets on the first and second spire whorl, the group is retained in *Notovoluta.*

The systematic position of the genus itself is in doubt since the information available on the anatomy of *N. verconis* and *N. kreuslerae* precludes its placement in any of the existing subfamilies. Weaver and du Pont (1970), the only authors to consider its systematic position, placed it in the Scaphellinae near *Amoria,* without any explanation for their action. The anatomy, so far as it is known (Darragh, 1983), has no close affinity with *Amoria,* as the gland of Leiblein is tightly bound to the oesophagus and cannot be easily separated as in *Amoria* and most other volutes. Also, though the radula is typically uniserial and tricuspid unlike that of *Amoria,* the cusps are somewhat fanglike and therefore quite unlike the radulae of most other Australian volutes. On the other hand, the anterior digestive system is similar to that found in most other Australian volutes including *Amoria.* Until more information on *Notovoluta* is available it does not seem appropriate either to erect a new subfamily for the reception of the genus, or to attempt to place it in an existing subfamily.

The earliest known species of *Notovoluta* occur in the Late Eocene of South-eastern Australia and

there are 9 other taxa distributed through the middle and late Tertiary including one species still living. There are no obvious ancestors of *Notovoluta* known, nor are there any close relatives and its origin is obscure at present.

Group One

Notovoluta variculifera sp. nov.

Plate 3, figures 7, 9, 13, 14

Description. Shell narrowly fusiform with gently convex whorls, capped by dome shaped protoconch of 3 whorls. First teleconch whorl flat and sculptured with thin, somewhat irregular, weak, axial plicae. Remainder of teleoconch whorls regularly convex from suture to suture, spiral sculpture of numerous close set threadlets which are present over whole surface of shell. Outer lip of aperture thickened externally and internally so as to form almost a varix. Columella with 4 plaits, anterior of which is weakest. Rarely an extra, weak, posterior plait present. Siphonal notch and fasciole absent.

Dimensions. Holotype (P48599) L33, HA17, W11; Paratype (P48600) L37, HA20, W12.

Location of types. National Museum of Victoria: Holotype P48599, coll. T.A. Darragh, 25 Feb 1971; Paratype P48600, coll. T.A. Darragh, 20 Nov 1970.

Type locality. FL14, BC III, dark gritty clay in washout 2, forked gully nearest mouth of Johanna River, Johanna (Glenaire 079059). Browns Creek Clay, Aldingan.

Stratigraphic range. Aldingan (Late Eocene-Early Oligocene).

Occurrence. FL13, Washout nearest Browns Creek; FL14, type locality; FL19, Point Flinders.

Material. Types and 6 other specimens.

Comments. This species is probably ancestral to *N. ellipsoidea*, though no intermediates between the two are known from the Late Oligocene to the Early Miocene. It differs from *N. ellipsoidea* by its narrower and smaller shell, in the presence of axial sculpture, in its more prominent sculpture on all the whorls and it lacks a siphonal notch and fasciole. It also bears some resemblance in size and shape to *N. cathedralis*, but lacks the prominent shoulder and shoulder nodules of that species.

Notovoluta capitonica sp. nov.

Plate 3, figures 8, 11, 12, 15
Plate 27, figures 1, 4

Description. Shell elongate with gradate spire. Protoconch turbinate, almost pupiform, of 2½–3 smooth whorls with impressed sutures. First teleconch whorl flat and bearing thin axial costae and fine spiral threads. Subsequent 2 or 3 spire whorls shouldered and bearing axial costae which are weak or absent on posterior whorl slope but well developed from shoulder to anterior suture. Remainder of teleconch whorls not prominently shouldered nor axially costate, but are merely covered with fine spiral threads. Columella with 4 strong plaits. Siphonal notch not preserved, siphonal fasciole well developed.

Dimensions. Holotype, aperture broken, (P126803) L74(est), HA–, W25; Paratype (P32209) L35, HA17, W12; Paratype, broken, (P32210) L43, HA–, W–.

Location of types. National Museum of Victoria: Holotype P126803, Coll. T.A. Darragh 9 May 1979; Paratype P32209, coll. T.A. Darragh 20 Nov 1970, Paratype P32210, coll. T.A. Darragh, and H.E. Wilkinson, 6 Dec 1968.

Type locality. FL11, BC1, 9.6 m dark clay with *Turritella* below greensand in washout 1 nearest mouth of Browns Creek, Johanna (Glen Aire 080057). Browns Creek Clay, Aldingan, late Eocene.

Stratigraphic range. Aldingan, late Eocene.

Occurrence. Type locality; FL10, Lower beds, Aldinga Bay.

Material. Types and 2 topotypes, 3 specimens from Aldinga Bay SAM P6567.

Comments. The axial costae on the juvenile spire whorls and the spiral threads over the whole spire distinguish this species from others in the genus. It is probably ancestral to *N. cathedralis* and *N. pseudolirata* however, as yet there is no record in the Oligocene of any similar species of *Notovoluta*.

Notovoluta pseudolirata (Tate)

Plate 4, figures 2, 4
Plate 5, figures 2, 10–12
Figure 9

Voluta pseudolirata Tate, 1888: 176, pl. 13, fig. 6 (figure).–Tate, 1889b : 131 (description).

Voluta (Aulica) pseudolirata.–Harris, 1897: 104.

Notovoluta pseudolirata.–Cotton, 1949: pl. 14.–Wilson, 1972: 349, pl. 32, figs 4–7.

Description. Shell elongate, fusiform, with shouldered whorls. Protoconch domeshaped of 2½ whorls. First and second teleoconch whorls gently convex, remainder of whorls prominently shouldered. Spiral sculpture absent. Axial costae somewhat variable in development and strength. Usually first and second spire whorls sculptured with thin costae and later whorls bear 9–15 costae which become nodulate on shoulder. Rarely, shell is

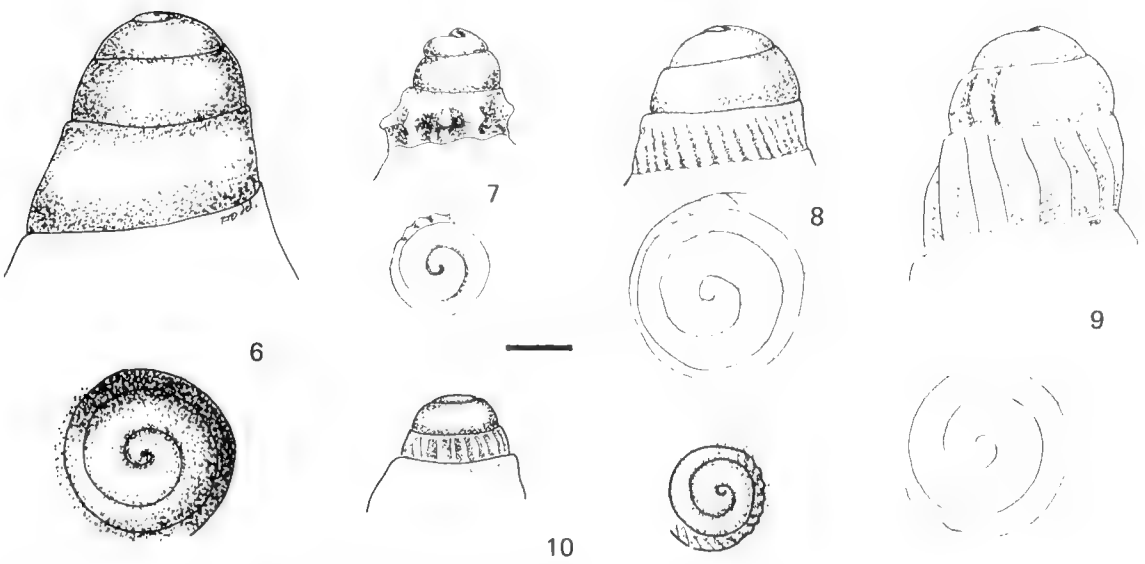

Figure 6. *Notovoluta kreuslerae kreuslerae* (Angas), Gabriel collection 1561, SA.
Figure 7. *Notovoluta tabulata* (Tate), SAM P5740a, hypotype Minderie, SA.
Figure 8. *Notovoluta kreuslerae occulta* sp. nov., WAM 69.389a, holotype, Quarry, 1.5 km N of Hampton Tower, WA.
Figure 9. *Notovoluta pseudolirata* (Tate) P32211, hypotype, Clifton Bank.
Figure 10. *Notovoluta linigera* sp. nov., P32218, paratype, SE side of Fischers Point. (scale = 2 mm)

smooth apart from a few incipient costulae. Siphonal notch deep, siphonal fasciole prominent. Colour cream with pattern of triangular spots and broad orange, spiral bands.

Dimensions. Holotype (T608C) L57, HA30, W19; T608D, L62, HA32, W19; Hypotype (P32211) L67, HA35, W22.

Location of types. South Australian Museum: Holotype T608C, R. Tate Collection. National Museum of Victoria: P32211, T.S. Hall in F.A. Cudmore Collection.

Type locality. Lower bed, Muddy Creek, i.e., FL82, Clifton Bank, Muddy Creek near Hamilton (Coleraine WD820224). Muddy Creek Formation, Balcombian, Middle Miocene.

Stratigraphic range. Balcombian, Middle Miocene–Recent.

Occurrence. Fossil: FL69, Red Bluff; FL70, Farells; FL71, SW of Glenleigh; FL72, Orphanage Hill, Fyansford; FL78, Fossil Beach, FL81, Overburden Batesford Quarry; FL82, Type locality; FL87, NW shore Lake Bullenmerri; FL88, NW end of Gibson Beach; FL103 Downstream section, Gunyoung Creek; FL104, Manyung Rocks.

Recent: In addition to the localities listed by Wilson 1972 the species has been dredged from the following: WAM 483-72, NW of Bunbury (33°S, 114°37'E), 212-226 m, HMAS "Diamantina", DM 1/72, Stn 6, 18 Mar 1972.

WAM 484-72, NNW of Cape Hamelin (34°10'S, 114°03'E), 148 m HMAS "Diamantina" DM 1/72, 16 Mar 1972.

Material. Holotype and 17 topotypes.

Comments. Traces of colour pattern in the form of triangular spots and spiral bands are present on fossils from Muddy Creek and Fossil Beach in positions similar to those of the living species. The development of the axial sculpture is variable but the living species fall within the range of variation of topotypes. It differs from *N. kreuslerae*, the other large species in the genus, by its more elongate spire.

Notovoluta cathedralis (Tate)

Plate 2, figures 14, 15
Plate 4, figures 3, 5

Voluta cathedralis Tate, 1888 : 176, pl. 13, fig. 10 (figure).—Tate, 1889b: 131. (description).
Scaphella (Eopsephia) cathedralis.—Harris, 1897: 117.
Notovoluta cathedralis.—Cotton, 1949: pl.15.

Description. Shell elongate with high tapering spire capped by small low dome-shaped protoconch. Protoconch of 2 smooth whorls and half a whorl sculptured with close-set axial ribs. First 2 teleoconch whorls almost flat, sculptured with fine close set spiral threads which continue and are present on posterior third of body whorl. Penultimate and body whorls bearing elongate nodules (8–10 on body whorl) which tend to become obsolete towards aperture. Siphonal notch wide and

deep, siphonal fasciole present.

Dimensions. Holotype (T596B) L47, HA25, W15; Hypotype (P32213) L42, HA21, W14.

Location of types. South Australian Museum: Holotype T596B, R. Tate Collection. National Museum of Victoria: Hypotype P32213, T.S. Hall in F.A. Cudmore Collection.

Type locality. Lower beds, Muddy Creek, t.e., FL82, Clifton Bank, Muddy Creek, Hamilton (Coleraine WD820224). Muddy Creek Formation, Balcombian, Middle Miocene.

Stratigraphic range. Balcombian, Middle Miocene.

Occurrence. FL74, SE Trunk Sewer at Junction Road; FL75, SE Trunk Sewer between Braeside and Centre Dandenong Rd; FL82, Type locality; FL84, Cadell Marl.

Material. Holotype and 30 topotypes.

Comments. This species is distinguished by the elongate nodules and the presence of spiral threads on the posterior slope of the whorls. The species is relatively common at the type locality and rare elsewhere. It bears a somewhat similar relationship to *N. verconis* as *N. pseudolirata* does to *N. kreuslerae*, however *N. verconis* has a prominent shoulder which is absent in *N. cathedralis*.

Notovoluta ellipsoidea (Tate)

Plate 2, figure 3
Plate 3, figure 2
Plate 5, figures 4, 5

Voluta ellipsoidea Tate, 1888: 176, pl. 13, fig. 4 (figure). Tate, 1889b: 127 (description).
Voluta (Aulica) ellipsoidea. Harris, 1897: 105.
Voluta (Aulica) sexuaplicata Chapman, 1922: 15, pl. 3, fig. 24.
Fricusa ellipsoidea. Cotton, 1949: pl. 15.
Fricusa (Fricusa) ellipsoidea. Ludbrook, 1958: 76.

Description. Shell narrowly fusiform with gently convex whorls capped by prominent subcylindrical or rarely domeshaped protoconch of 2½–3½ smooth whorls. First teleoconch whorl flat to concave, remainder of whorls gently convex and occasionally slightly depressed against posterior suture of whorl. Axial sculpture absent. Spiral sculpture of numerous close-set threadlets which are present over whole of whorls but are stronger and more obvious on first and second teleoconch whorls and decrease in strength on subsequent whorls. Aperture notched posteriorly at suture. Columella with 4 strong plaits. Siphonal notch shallow and wide; siphonal fasciole prominent.

Dimensions. Holotype (T601C), L53, HA28, W18; Hypotype (T601A), L68, HA40, W24; P13250, L71, HA38, W23.

Location of types. South Australian Museum: Holotype T601C, Hypotype T601A,. Tate Collection. National Museum of Victoria: Holotype of *V. (A.) sexuaplicata* P13250, Pres. G .P. Tait, 22 Jul 1907.

Type locality. Lower beds, Muddy Creek, t.e., FL82, Clifton bank, Muddy Creek, Hamilton (Coleraine WD820224). Muddy Creek Formation, Balcombian, Middle Miocene.

Stratigraphic range. Balcombian, Middle Miocene–Yatalan, Late Pliocene.

Occurrence. FL82, type locality; Gellibrand Marl (Bairnsdalian):Cliff 5 km NW of Point Ronald, Princetown. Dry Creek Sands (Late Pliocene):Abattoirs Bore (fide Ludbrook, 1958).

Material. Types and 8 topotypes.

Comments. The absence of any axial sculpture and the overall fine spiral threads distinguish this species from others in the genus. The holotype of *Voluta (Aulica) sexuaplicata* is worn, particularly on the posterior portion of the spire. There are however faint spiral threads present and the protoconch is typically that found in *N. ellipsoidea*. This specimen is merely a narrow individual of *N. ellipsoidea* which has an extra two weak columella plaits.

Notovoluta tabulata (Tate)

Plate 4, figures 1, 6, 8, 10
Figure 7

Voluta tabulata Tate, 1888: 176, pl. 13, fig. 3 (figure) Tate, 1889b:132 (description).

Description. Shell fusiform with rather short gradate spire of prominently shouldered whorls. Protoconch somewhat dome-shaped, of 2½ swollen whorls, latter half whorl bearing axial plicae which on anterior half of teloconch whorls develop into more prominent costae. Spiral sculpture absent. Body whorl with 9–10 rather sinuous costae which are subspinose on shoulder, are absent from posterior whorl slope and fade out at middle of anterior whorl slope. Anterior half of body whorl abruptly contracted to the anterior canal.

Dimensions. Holotype (T611A), L36, HA22, W16; 1611B, L38, HA–, W17; Hypotype (SAM P5740a), L38, HA20, W16; Hypotype (SAM P5740b), L37, HA19, W14.

Location of types. South Australian Museum: Holotype 1611A, R. Tate Collection; Hypotypes P5740a–b, "old collection".

Type locality. "Well-sinking. Murray Desert" (Tareena, NSW). Bookpurnong beds, late Miocene. Tate (1899:102) stated that the species described from the "Murray Desert"

in previous papers came from a deep well at Tareena, NSW.

Stratigraphic range. Cheltenhamian, Late Miocene.

Occurrence. Bookpurnong Beds (Cheltenhamian): type locality; Well sinking at Mindarie, South Australia.

Material. Holotype, 1 topotype and 2 other specimens.

Comments. The species is distinguished by the low spire and subspinose costae. This, the nominate subspecies, is ancestral to *N. tabulata* subsp. from the Dry Creek Sands. Of the other species of *Notovoluta* it seems to come closest to *N. verconis* (Tate) but differs in the points mentioned above.

Notovoluta tabulata subsp. nov.

Description. Shell fusiform with gradate spire of prominently shouldered whorls. Protoconch dome-shaped as in *N. kreuslerae*. Spiral sculpture absent. Shoulder of whorls bearing prominent subspinose projections, of which there are about 8 on body whorl. These projections are posterior portions of axial costae which are frequently poorly developed. Body whorl abruptly contracted anteriorly and having prominent siphonal fasciole.

Occurrence. Dry Creek Sands, various bores, Adelaide Plains, SA.

Comments. This subspecies is currently under study by Dr H.H. Ludbrook, but is included in order that the list of species might be complete. *Notovoluta tabulata tabulata*, which is probably ancestral to this subspecies, is more elongate, has more persistant axial sculpture and the whorls of the protoconch are swollen. In view of the variation in morphology of the Dry Creek Sands specimens and because of the paucity of specimens of *N. tabulata tabulata* this taxon is regarded as a subspecies of the latter.

Notovoluta verconis medicata subsp.nov.

Plate 29, figures 1–6

Notovoluta verconis.—Ludbrook, 1978: 166, pl. 18, fig. 19.

Description. Shell elongate, fusiform with high spire and weakly shouldered whorls. Protoconch, dome-shaped of 2 smooth whorls and third whorl sculptured with close-set weak axial riblets. Teleoconch weakly shouldered and sculptured with axial costae which are often weakly developed overall and sometimes becomes obsolete on body whorl. Spiral sculpture of very fine close-set threads confined to shoulder of whorls. Columella with 4 strong plaits, weak posterior plait and often 1 or more weak plaits inserted between the others.

Dimensions. Holotype (WAM 79.2595), L29, HA17, W11; Paratype (P59665), L30, HA15, W12; Paratype (WAM 76.2399), L32, HA18, W12.

Location of types. Western Australian Museum: Holotype WAM 79.2595, coll. V.A. Ryland, G.W. and W.E. Kendrick, 5–13 Aug 1978; Paratype WAM 76.2399, coll. P.J. Bridge and K. Williamson, Apr 1973. National Museum of Victoria: Paratype P59665 coll. T.A. Darragh 24 Apr 1969.

Type locality. Quarry 1.5 km N of Hampton Microwave Repeater Tower, Roe Plain Western Australia. (Eucla, 1:250,000 365465). Roe Calcarenite.

Stratigraphic range. Roe Calcarenite.

Occurrence. Type locality; Foundation holes for Hampton Microwave Repeater Tower; Nurina Cave, Roe Plain, Western Australia.

Material. Types, 11 topotypes and 3 other specimens.

Comments. This taxon is close to *N. verconis verconis* (Tate) but may be distinguished by its more weakly developed shoulders and therefore less gradate spire. The body whorl is not as swollen and the axial costae tend to be much weaker and more numerous (13–18 on penultimate whorl as against 11–13) and are often virtually absent from the body whorl. As these differences seem to be somewhat gradational the taxon is regarded as a subspecies of *N. verconis. Notovoluta occidua* Cotton is much narrower, has virtually no shoulder and the axial costae are much more strongly developed.

Notovoluta kreuslerae occulta subsp. nov.

Plate 29, figures 11–14
Figure 8

Notovoluta kreuslerae subtilis Ludbrook, 1978 : 166 (in part).

Description. Shell elongate, fusiform, with rather flattened whorls. Protoconch dome-shaped of 2½–3 smooth whorls. First teleoconch whorl almost flat, sculptured with close-set axial costae on first half of whorl. Remainder of spire whorls and body whorl usually smooth except for growth striae, but rarely with weakly developed axial plicae. Spire whorls and body whorl on some specimens with weakly developed shoulder. Columella with 4 strong plaits. Siphonal notch, wide and deep; siphonal fasciole present.

Dimensions. Holotype (WAM 79.389a). L72, HA40, W25; Paratype (WAM 76.2476), L72, HA40, W29; Paratype (P53038), L60, HA33, W22; P53037, L64, HA37, W24.

Location of types. Western Australian Museum: Holotype WAM 79.389a, coll. V.A. Ryland, G.W. and W.E.

Kendrick, 5–13 Aug 1978. WAM 76.2476 coll. E. and N. Zeffert, Jan 1976. National Museum of Victoria: P53038 coll. T.A. Darragh, 21 Apr 1969.

Type locality. Quarry on access road to Hampton Microwave Repeater Tower, 1.5 km N of Tower, Roe Plain, Western Australia (Eucla, 1:250,000 365464). Roe Calcarenite, Early Pleistocene.

Stratigraphic range. Early Pleistocene.

Occurrence. Type locality and various borrow pits in the Roe Calcarenite along Eyre Highway, Roe Plain, Western Australia.

Material. Types, 5 topotypes and 13 other specimens.

Comments. This subspecies differs from *Notovoluta kreuslerae kreuslerae* by its more slender shape, by the lack of a well defined shoulder and lack of prominent axial sculpture. However as Ludbrook has indicated, there is some degree of variability in morphology and, indeed, of overlap between the Pleistocene and living forms, therefore the writer agrees with Ludbrook and maintains subspecific rank for the Pleistocene taxon.

The holotype of *Notovoluta kreuslerae subtilis* is an *Ericusa* which leaves the subspecies of *Notovoluta* without a name. The paratypes WAM 69.606 are specimens of this subspecies of *Notovoluta*. The two taxa which have been confused are somewhat similar in overall morphology but may be separated by the protoconchs, that of *N. kreuslerae occulta* is coiled in the axis of the shell, that of *Ericusa subtilis* is deviated. *Ericusa subtilis* also has no axial sculpture.

Notovoluta kreuslerae kreuslerae (Angas)

Plate 5, figures 1, 7
Figure 6

Voluta (Alcithoe) kreuslerae Angas, 1865: 55, pl. 2, fig. 3.

Voluta kreuslerae. – G.B. Sowerby III, 1887: 299, pl. 515, fig. 150.

Voluta rossiteri Brazier, 1898: 779.

Notovoluta kreuslerae. – Weaver and du Pont, 1970: 168, pl. 72J, 72K.

Notovoluta rossiteri. – Weaver and du Pont, 1970: 168, pl. 72F, 72G.

Notovoluta kreuslerae. – Wilson, 1972: pl. 32, fig. 13.

Comments. Weaver and du Pont (1970) have provided a good description and figures of this species. However, in their citation of Portland, Victoria, as type locality, they have overlooked the fact that Angas cited Glenelg, South Australia as the origin of his specimen. Wilson (1972:348) has pointed out that the holotype of *Voluta rossiteri* Brazier is merely a large specimen of *N. kreuslerae* and the writer agrees with this. This holotype is a beach worn specimen from Lakes Entrance, Victoria, and no other specimen has yet been found in Victorian waters, despite extensive dredging particularly off Gippsland.

The species is confined to South Australia and ranges from Cape Donnington to Encounter Bay.

Notovoluta verconis verconis (Tate)

Plate 2, figure 5
Plate 4, figure 7
Plate 5, figure 3

Voluta verconis Tate, 1892: 125, pl. 1, fig. 5.

Notovoluta verconis. – Weaver and du Pont, 1970: 169, pl. 72H, 72I; Fig. 37.. – Wilson, 1972: pl. 32, figs 10–12.

Comments. Weaver and du Pont (1970) have provided a good description and illustration of this species. It ranges from Nuyts Archipelago to Encounter Bay, South Australia.

Notovoluta occidua Cotton

Plate 2, figure 4

Notovoluta occidua Cotton, 1946: 16.

Notovoluta occidua. – Wilson, 1972: 348, pl. 32, figs 8, 9

Comments. This species was synonymised with *N. verconis* by Weaver and du Pont (1970), however, Wilson (1972) pointed out certain differences between the two taxa and accepted *N. occidua* as a good species. Unfortunately, there are as yet only a few worn specimens available from two restricted areas off Hopeton and off Eucla, W.A. and it is not possible to fully assess whether this is the case or not.

Notovoluta baconi Wilson

Plate 5, figures 6, 13

Notovoluta baconi Wilson, 1972:352, pl. 32, figs 1–3.

Comments. This species was founded on two specimens and no additional material is available. Wilson has provided a detailed description and comparison. It closely resembles *N. pseudolirata* from which it differs principally by the presence of more numerous axial costae on the penultimate and body whorls.

Notovoluta gardneri Darragh

Plate 27, figures 11, 14

Notovoluta gardneri Darragh, 1983: 84, Figs 1, 3, 6, 8.

Comments. This species is distinguished from the other known living species by the absence of axial sculpture. In shape it most closely resembles the

Early Miocene *N. differta* sp. nov., but that species has numerous close-set threads covering the whole spire.

Group Two

Notovoluta saginata (Finlay)

Plate 2, figure 2
Plate 5, figure 8

Voluta lirata Johnston, 1880: 37 non Brocchi, 1814.
Voluta allporti.—Johnston, 1888: pl. 30, fig. 10, non Johnston, 1880.
Voluta maccoyi.—Pritchard, 1896: 95 (partim) non Tenison Woods, 1877.
Voluta lirata.—Pritchard, 1913: 197, pl. 20, figs 7, 8.
Notopeplum saginatum Finlay, 1930: 45.—Ludbrook, 1967: 67, pl. 3, figs 5, 7 (Holotype of *V. lirata*).

Description. Shell fusiform with elongate conical spire. Protoconch somewhat dome-shaped of 2 smooth whorls the second of which is swollen and half a whorl which has a few weak widely spaced riblets and 2 spiral threads. Spire whorls generally flat, rarely a little depressed posteriorly, sculptured with numerous slightly sinuous axial riblets which become obsolescent on body whorl. Body whorl a little ventricose, contracting rapidly to anterior canal. Columella with 4 strong plaits. Siphonal notch shallow, siphonal fasciole prominent.

Dimensions. Holotype (AIM TM1072), L51, HA32, W23; Hypotype (MUGD 1795), L32, HA18, W16 (Pritchard 1913, pl. 20, figs 7, 8); TM Z185, L47, HA28, W21 (Johnston, 1880: 37; 1888, pl. 30, fig. 10).

Location of types. Auckland Institute and Museum: Holotype TM 1072 H. Finlay Collection. Melbourne University Geology Department: Hypotype 1795, G.B. Pritchard Collection. Tasmanian Museum: Holotype of *Voluta lirata*, Z185, R.M. Johnston Collection.

Type locality. "Table Cape", Fossil Bluff, Wynyard, Tasmania (Table Cape 930630).

Stratigraphic range. Janjukian, Early Miocene.

Occurrence. FL28, Lower bed, Fossil Bluff; FL29, upper bed, Fossil Bluff.

Material. Numerous specimens from FL28; 6 specimens from FL29.

Comments. This species and the following three are closely related and are probably part of the same lineage. *N. saginata* is characterised by its ventricose appearance, by the elongate conical spire which is almost half the length of the shell and by the axial riblets present on the spire whorls. The specimen figured by Johnston (1888) as *Voluta allporti* is probably the holotype of *Voluta lirata*. For comment on *V. allporti* see *Ericusa pellita*.

Notovoluta linigera sp. nov.

Plate 3, figures 3, 4, 6, 10
Figure 10

Description. Shell ovate, rather squat, almost biconic. Protoconch of 1½–2 whorls, last whorl of which is axially plicate. Spire whorls depressed posteriorly, convex against anterior suture. Body whorl depressed posteriorly then gently convex and tapering anteriorly to canal. Axial sculpture of thin, close but somewhat irregularly spaced riblets. Spiral sculpture of thin close-set threads which are well developed and cover spire whorls but tend to decrease in strength anteriorly on body whorl and may be entirely obsolete on body whorl of large specimens.

Dimensions. Holotype (P32216), L33, HA19, W14; Paratype (P32218), L32, HA16, W13.

Location of types. National Museum of Victoria: Holotype P32216 coll. T.A. Darragh and T. Hughes 30 Nov 1972. Paratype P32218 coll. T.A. Darragh and H.E. Wilkinson 4 Dec 1968.

Type locality. FL35, Cliff section 10 m above Lake Craven, Aire River, SE of Fischers Point Horden Vale (Princetown 155040). Lower mollusc horizon, Fishing Point Marl. Longfordian.

Stratigraphic range. Longfordian, Early Miocene.

Occurrence. FL32, SE end of Jan Juc Beach; FL34, S bank of Lake Costin; FL35, Type locality.

Material. Types and 8 topotypes, several other specimens.

Comments. This is a more slender shell than *N saginata* and has more prominent spiral threads and axial sculpture. *N. lintea* has similar spiral threads but the axial sculpture consists of widely spaced, elongate nodules rather than closely spaced fine riblets. The spiral sculpture on specimens from the Puebla Clay is not as strongly developed as on those from Horden Vale.

Notovoluta differta sp. nov.

Plate 4, figures 11–14

Description. Shell ovate with rapidly tapering spire. Protoconch dome-shaped, of 2 smooth whorls, and half a whorl with poorly developed axial plicae. First and second teleoconch whorls flat, subsequent whorls depressed posteriorly and convex anteriorly. Axial sculpture absent. Spiral sculpture of numerous close-set threads covering whole of spire whorls and posterior third of body whorl. Aperture as in *N. saginata*. Siphonal notch shallow; siphonal fasciole present. Colour pattern of thin, widely spaced, sinuous, axial bands.

Dimensions. Holotype (P32221), L51, HA33, W20; Paratype (P32222), L49, HA32, W20.

Location of types. National Museum of Victoria: Holotype P32221, coll. T.A. Darragh and H.E. Wilkinson, Paratype P32222, G.B. Pritchard Collection.

Type locality. FL43, cutting on Lavers Hill - Cobden Rd, 0.8 miles S of Kennedys Creek turnoff (Princetown 969253). Gellibrand Marl, Batesfordian.

Stratigraphic range. Batesfordian, Early Miocene.

Occurrence. FL38, Curlewis; FL42, Amphitheatre; FL43, Type locality; FL48, Boornong Rd cutting.

Material. Holotype, 5 topotypes and 11 other specimens.

Comments. The shell of this species is not so tumid as in *N. saginata* and there is an incipient shoulder developed which is not present in the latter. *N. lunigera* has prominent axial sculpture and *N. lintea* has elongate nodules which are not present in the species under consideration.

Notovoluta lintea (Tate)

Plate 3, figures 1, 5
Plate 4, figure 9

Voluta lintea Tate, 1889b: 129, pl. 3, figs 1a, b.
Notovoluta lintea. - Cotton, 1949: pl. 15.

Description. Shell elongate ovate with slender spire. Protoconch dome-shaped of 2½ whorls the last half whorl of which axially plicate. First teleconch whorl flat, penultimate and final whorls depressed in front of posterior suture. Suture grooved. Spiral sculpture of numerous close-set threads which tend to decrease in strength on body whorl. Axial sculpture of widely spaced, low, elongate nodules present on the penultimate and final whorls and situate in front of posterior depression of whorls. Columella with 4 strong plaits. Siphonal notch shallow; siphonal fasciole weak.

Dimensions. Holotype (T600), L 27, HA15, W11; Hypotype (P32219), L 27, HA17, W10; P32220, L 32, HA18, W11.

Location of types. South Australian Museum: Holotype T600, R. Tate Collection. National Museum of Victoria: Hypotype P32219, F.A. Cudmore Collection.

Type locality. "Calciferous sandstones of the River Murray Cliffs near Morgan". The locality is on the left bank of the River Murray at a gully 4.8 km S of Morgan-Cadell Rd, SA. (Renmark, 1:250000 268789). Cadell Marl lens, Morgan Limestone, Balcombian.

Stratigraphic range. Balcombian, Middle Miocene.

Occurrence. Type locality only.

Material. Holotype and 2 topotypes.

Comments. The widely spaced, low, elongate nodules and slender shape distinguish this species from the others in the group.

Volutoconus Crosse, 1871

Voluta (Volutoconus) Crosse, 1871: 306.

Type species. Monotypy: *Voluta coniformis* Cox 1871; Recent, Western Australia.

Distribution. Northern Australia (North-west Western Australia–Northern New South Wales).

Comments. There are four living species in the genus. All previous fossil records attributed to this genus are based on species of *Nannamoria* and are discussed under that genus.

Volutoconus sp.

Remarks. This record is based on a single silicified juvenile specimen from the Mid Miocene Trealla Limestone at Geological Survey of Western Australia locality 30055, E flank of Cape Range near Exmouth, Western Australia. The specimen consists of four protoconch whorls and one teleoconch whorl. The protoconch bears well-defined axial costae much narrower than the interspaces. Teleoconch whorl has numerous close set costae and there are four strong plaits on the columella. The specimen bears a close resemblance to *Volutoconus hargreavesi* which occurs in off-shore waters from Houtman Abrolhos to the Dampier Archipelago, North-west Western Australia.

Amoriinae subfam. nov

Diagnosis. Head broad, flat, entire with short flat tentacles. Siphonal appendages short, flat and equal. Operculum absent. Tubular salivary glands of anterior digestive system very short and free from racemose salivary gland. Radula uniserial, usually Y-shaped and consisting of single cusp or sometimes tricuspid. Protoconch multispiral with whorls coiled in axis of shell. Shell covered with hard brilliant glaze. Aperture usually with 4 strong plaits and occasionally with 1 or more weaker secondary plaits.

Remarks. The subfamily has been erected for the reception of *Amoria* and *Nannamoria*, genera which have been placed in the Scaphellinae by previous authors, on the basis of a rather superficial resemblance of the radulae of *Scaphella* and *Amoria*. The animal of *Scaphella*, described by Clench and Turner (1964), however differs principally from *Amoria* by having a cleft head similar to that present in the Volutinae and Athletinae, a single left siphonal appendage and a gland of

Leiblein which is bound to the oesophagus and cannot be separated as in *Amoria*.. These features are of sufficient magnitude to warrant subfamily separation of *Amoria* and *Scaphella*.

The anatomy of *Scaphella* has certain "primitive" features, e.g. the cleft head, resembling those of the Volutinae and Athletinae, a situation reflected by the geological record of this group, since *Scaphella* is known from the Late Cretaceous and Paleocene of Europe and hence qualifies as one of the earliest volutes. Members of the Amoriinae, however, are known only from the latest Oligocene or Early Miocene and the anatomical features of the group are closer to those found in the Zidoninae.

The principal difference between the Amoriinae and Zidoninae is the presence of a short tubular salivary gland free from the racemose salivary gland in the former, in contrast to a very long tubular salivary gland loosely associated with the racemose gland in the latter.

The oldest known members of the family appear in the latest Oligocene or Early Miocene and the family is known only from the Australian region. In view of the similarity of the anatomy and shell characters to members of the Zidoninae, particularly *Cymbiola,* it is suggested that the Amoriinae is derived from the former in the early Tertiary.

Amoria Gray, 1855

Amoria Gray, 1855b: 64.

Voluta (Amoria).—Tryon, 1882: 92.—Fischer, 1883: 608.—Harris, 1897: 108.

Amoria—Cossmann, 1899: 119.

Scaphella.—Hedley, 1915: 721 (non Swainson, 1832).

Amoria (Amorena) Iredale, 1929: 180 (Type species (original designation): *Voluta undulata* Lamarck).

Amoria (Zebramoria) Iredale, 1929: 180 (Type species (original designation): *Voluta zebra* Leach).

Cymbiola (Cymbiolista) Iredale, 1929: 181. (Type species (original designation): *Voluta marmorata* Swainson).

Relegamoria Iredale, 1936: 314 (Type species (original designation): *Regelamoria moleri* Iredale, 1936).

Amorena.—Cotton and Godfrey, 1932: 47.

Amoria.—Smith, 1942: 50.

Amoria (Amoria).—Wenz, 1943: 1339.

Amoria (Zebramoria).—Wenz, 1943: 1339.

Amoria (Amorena).—Wenz, 1943: 1339.

Adelomelon (Cymbiolista)—Wenz, 1943: 1349.

Cymbiolista.—McMichael, 1960: 11.

Amorena.—Macpherson and Gabriel, 1962: 222.

Zebramoria.—Macpherson and Gabriel, 1962: 223.

Amoria.—McMichael, 1964: 265.

Zebramoria.—McMichael, 1964: 271.

Amoria (Amoria).—Weaver and du Pont, 1970: 147, 148.

Amoria (Amorena).—Weaver and du Pont, 1970: 159.

Amoria (Relegamoria).—Weaver and du Pont, 1970: 162.

Amoria (Zebramoria).—Weaver and du Pont, 1970: 163.

Cymbiolista.—Weaver and du Pont, 1970: 171.

Amoria.—Wilson, 1972: 340.

Type species. Subsequent designation by Harris (1897): *Voluta turneri* Griffith and Pidgeon, 1834; Recent, Northern Australia.

Description. Shell fusiform or elongate-ovate with subconical or rarely gradate spire; spire whorls usually flat though sometimes weakly shouldered, body whorl shouldered. Protoconch multispiral, conical, coiled with axis of shell, of 3½–4½ smooth, flat or convex whorls, which may or may not have narrow shoulder. Surface of shell shining, generally smooth but occasionally with weakly developed axial costae or nodules. Aperture narrow, somewhat elliptical, slightly notched posteriorly; columella with 4 strong plaits and occasionally with extra 1 or 2 weaker plaits. Siphonal notch deep; siphonal fasciole usually prominent.

Stratigraphic range. Middle Miocene–Recent.

Distribution. Australian waters generally and south-eastern Indonesia. 0–500 metres. Victoria and South Australia. (Middle Miocene–Recent), Western Australia (Middle Miocene, Pleistocene–Recent).

Comments. In the above synonymy, references which merely cite names have been omitted, and only those which include descriptions or discussions of generic taxa are included.

Wenz (1943) and Ludbrook (1953) both synonymised without comment *Relegamoria* with *Amoria* and have been followed by McMichael (1964) who stated that the radula of the former was typical of *Amoria* and the apical characters could not be distinguished from other species of *Amoria.* However, Weaver and du Pont (1970) have resurrected *Relegamoria* stating that the ridgelike callus on the inner side of the outer lip, the pointed protoconch and the presence of a fifth columella plait are differential characters of sufficient importance to warrant subgeneric status for the taxon. The author agrees with Wenz, Ludbrook and McMichael that *Relegamoria* should be placed in synonymy with *Amoria,* since these features are variable from species to species and individual to individual, but would go further and on similar grounds also include *Amorena, Cymbiolista* and *Zebramoria.*

Amorena was erected with the bare statement that the form, apex and columella plaits differed from *Amoria,* and it is only recently that any

author has attempted to describe how these features differ. Weaver and du Pont (1970) stated that "*Amorena* differs from *Amoria* s.s. in having a smaller, irregularly coiled protoconch and stronger less oblique columella plaits, often with secondary plaits in between the normal ones". They included in the taxon *Amorena exoptanta* Reeve, *A. benthalis* McMichael (= *undulata*), *A. undulata* Lamarck and *A. sclateri* Cox (= *undulata*). The protoconchs of all these taxa are similar, but vary somewhat in size, all are coiled with the axis of the shell, are conical and consist of four or so whorls and fall within the range of variation of the protoconchs found in species assigned to *Amoria*. The so-called irregular coiling presumably refers to that fact that in *A. undulata* the whorls of the protoconch are convex, whereas the spire whorls are flat, so that the top of the spire has a knoblike appearance. The strength of development of the plaits is subject to individual variation, as is the number present. Generally there are four plaits present in *A. undulata* and only rarely are others found, so this cannot be of generic significance. In elongate specimens of *A. undulata* the plaits are as oblique as in *A. grayi* or any other elongate *Amoria*, so that the alleged differences are not of any significance and *Amorena* cannot be maintained.

Cymbiolista Iredale, 1929 was erected as a subgenus of *Cymbiola* without diagnosis, and later was raised to the rank of genus without comment by Iredale (1931). The type and only species, *Cymbiolista hunteri* Iredale (= *marmorata* Swainson), was placed in *Amoria* by Smith (1942) following Tryon (1882). McMichael (1960) described the radula of *C. hunteri* as of the *Amoria* type, placing the genus *Cymbiolista* with *Amoria* in the subfamily Scaphellinae, and commented that the shell did not resemble *Amoria* in any way. The author disagrees with the latter statement. The conical multispiral protoconch, aperture, plaits, siphonal notch and fasciole, colour pattern (for what it is worth) and overall appearance are typical of species of *Amoria*. The only difference is that the shoulder is sharply nodulate on the edge, a feature which the author regards as of specific rather than generic significance.

Iredale (1929) erected *Zebramoria* on the grounds that it differed from *Amoria* in the same details as his subgenus *Amorena*. Subsequent authors, e.g. Weaver and du Pont (1970) have noted only the difference in the protoconch, "with the exception of the protoconch whorls and early teleoconch whorls the shell morphological characteristics of *Zebramoria* confirm to those of *Amoria*". The protoconch is multispiral of 2½–3 smooth whorls, coiled in the axis of the shell. The protoconch is a miniature version of that found in *A. undulata*, except that it is not as squat and the whorls are more swollen, giving a pupiform appearance to the protoconch. These differences are not considered to be sufficient grounds for the separation of *Zebramoria* from *Amoria* and accordingly it has been synonymised with the latter.

An examination of the animal has shown that the external morphology, the radula and the anterior digestive system of the type species of *Relegamoria, Cymbiolista, Amorena* and *Zebramoria* are identical to those found in the various species of *Amoria*, which confirms the above observations based on shell morphology.

The oldest representatives of the genus *Amoria*, *A. costellifera* (Tate) and *Amoria* sp. occur respectively in the Middle Miocene of south-eastern Australia and North-west Australia and there are no obvious ancestors in the Australian Tertiary. A second species, *A. undulata* (Lamarck) which is still living in the area, makes its appearance in the Late Miocene, however, there is no direct connection between these two species. In the past *Amoria* has tended to be regarded as a tropical genus, because many species have been described from Northern Australia, however the significance of the genus in that area has been overemphasised, since most of these taxa are merely colour varieties and the number of good species is quite small. There are no known representatives of the genus in the Tertiary rocks of Java, Timor or New Guinea which may indicate that *Amoria* is a new immigrant into that area.

The relationships of the genus are not clear and the poor stratigraphic record throws no light on the problem. On the basis of general shell morphology and the anatomy, some relationship with *Cymbiola* and possibly *Notovoluta* is suggested.

Amoria costellifera (Tate)

Plate 6, figures 4, 8, 10–12
Figure 11

Voluta lirata Tate, 1889b: 130, pl. 2, fig. 4 (non Johnston, 1880).
Voluta costellifera Tate, 1889b: 131, pl. 2, fig. 8.
Voluta (Aulica) lirata.—Harris, 1897: 103, pl. 4, fig. 12.
Nannamoria absidata Cotton, 1949: 192, pl.14.
Nannamoria costellifera.—Cotton, 1949: pl. 14.

Description. Shell fusiform with gradate to subconical spire. Protoconch smooth, conical of 3½ whorls with grooved suture. Whorls usually depressed posteriorly then concave and generally

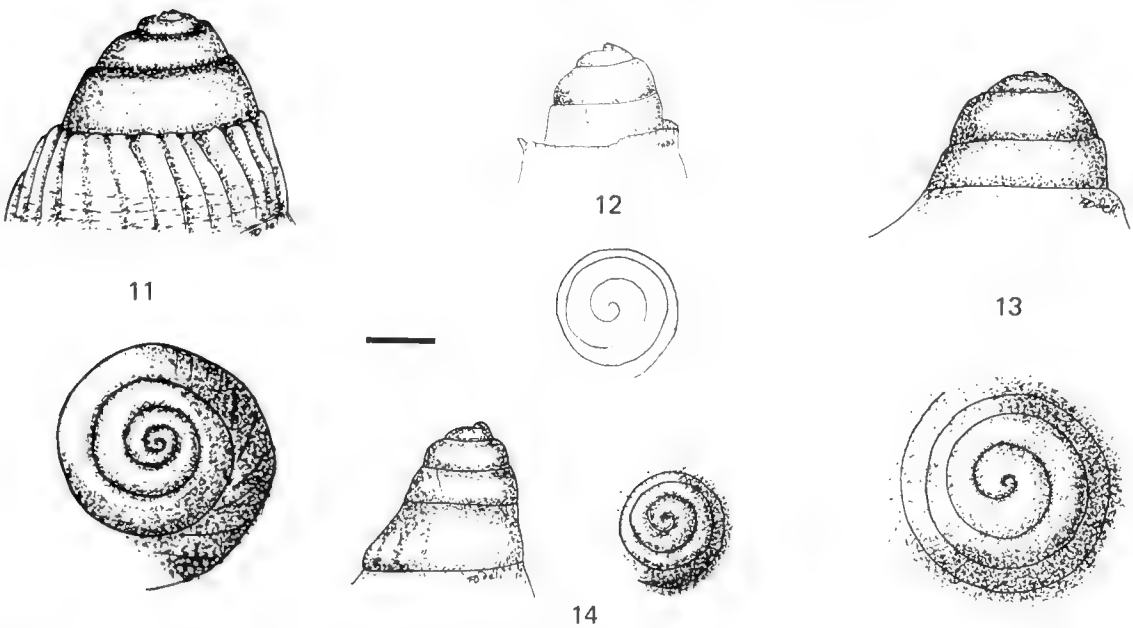

Figure 11. *Amoria costellifera* (Tate), P61286, hypotype, Clifton Bank.
Figure 12. *Nannamoria limbata* (Tate), P33087, hypotype, Manyung Rocks.
Figure 13. *Nannamoria strophodon guntheri* (Smith), St. Francis Is., SA.
Figure 14. *Nannamoria amicula* Iredale, F21294, off Broken Bay, NSW. (scale = 2 mm)

prominently shouldered. Axial sculpture of relatively broad low costae, variable in degree of development and number per whorl. First teleconch whorl usually sculptured with coarse close-set costae. Spiral sculpture absent. Columella generally with 4 plaits; siphonal notch broad; siphonal fasciole prominent. Colour pattern of thin close set axial bands which zig-zag on slope of shoulder of whorl and bifurcate on shoulder itself.

Dimensions. Holotype (T603), L61, HA44, W29; T597B, L63, HA42, W25 (Tate, 1889, p. 130, pl. 2, fig. 4); Hypotype (P34261), L74, HA51, W30.

Location of types. South Australian Museum. Holotype T603; Holotype of *Nannamoria absidata* Cotton T597B, R. Tate Collection. National Museum of Victoria: Hypotype, P34261, F.S. Colliver Collection; Hypotype P61286, G.B. Pritchard Collection.

Type locality. Lower beds, Muddy Creek, i.e., FL82, Clifton Bank, Muddy Creek near Hamilton (Coleraine WD820224). Muddy creek Formation, Balcombian, Middle Miocene.

Stratigraphic range. Balcombian-Bairnsdalian, Middle Miocene.

Occurrence. FL78, Fossil Beach; Griffins (=Retreat Farm), 0.2 km due N of FL80; FL82, Type locality; FL84, 4 miles below Morgan; FL87, Lake Bullenmerri; FL100, Murgheboluc 4A; FL103, downstream section, Gunyoung Creek; FL104, Manyung Rocks.

Material. Types and 20 topotypes.

Comments. Pritchard (1896, 1913) has already pointed out that Tate's specimen figured as *Voluta lirata* Johnston and subsequently described as *Nannamoria absidata* Cotton, is the same species as that which bears the name *Voluta costellifera*. The Muddy Creek population of this species is rather variable in morphology. The ribs may be well or poorly developed, and numerous or few, the spire may be low or high and the whorls may or may not be depressed at the posterior suture. Tate's type of *V. costellifera* is rather wide with a low spire, whereas his specimen figured as *V. lirata* is more representative of the population as a whole.

Of recent species this taxon most closely resembles *Amoria exoptanda* (Reeve) from South Australia. The protoconch of the latter is similar, the spire whorls are depressed at the posterior suture and concave at the anterior, the juvenile colour pattern has some similarity and there is a suggestion of obsolete axial costae on the spire.

Amoria undulata masoni (Tate)

Plate 6, figures 5, 6, 9

Voluta masoni Tate, 1889b: 128, pl. 3, fig. 9.
Voluta (Amoria) masoni.—Harris, 1897: 110, pl. 4, fig. 14a, b.
Amoria masoni.—Cossmann, 1899: 120, pl. 5, fig. 10,

pl. 6, fig. 7.—Cotton, 1949: pl. 14

Description. Shell smooth, polished, ovate to subpyriform with squat conical spire and ventricose body whorl. Protoconch turbinate, of 3½ whorls, last usually slightly larger than succeeding teleoconch whorl. Spire whorls flat, body whorl flat or slightly concave between posterior suture and shoulder and abruptly contracted anteriorly. Colour pattern of thin, undulose, axial, chestnut bands with apricot coloured apertural glaze.

Dimensions. Lectotype (T385A), L59, HA–, W29; Hypotype (P34263), L69, HA50, W34.

Location of types. South Australian Museum: lectotype T385A (Tate's figured specimen); paralectotypes T385B-H, R. Tate collection. National Museum of Victoria: Hypotype P34263, F.S. Colliver Collection.

Type locality. Upper beds, Muddy Creek, i.e., FL139, Macdonalds bank, Muddy Creek, below Yulecart School (Coleraine WD827219). Grange Burn Formation, Kalimnan, Early Pliocene.

Stratigraphic range. Cheltenhamian, Late Miocene-Kalimnan, Early Pliocene.

Occurrence. FL132, Spring Creek, Minhamite; FL137, Forsythes Bank; FL139, Type locality.

Material. Types and 10 topotypes.

Comments. This subspecies differs from *A. undulata* s.s. by its squat conical spire and more ventricose bodywhorl. These differences are not regarded as being of sufficient magnitude to warrant specific distinction from *A. undulata*. Specimens from Spring Creek Minhamite often show signs of axial costae on the first teleoconch whorl not unlike those found in *A. zebra*.

Amoria undulata undulata (Lamarck)

Plate 6, figures 1-3, 7

Voluta undulata Lamarck, 1804: 157, pl. 12, fig. 1a, b.
Voluta sclateri Cox, 1869: 358, pl. 26, fig. 3.
Voluta kingi Cox, 1871: 76, pl. 4, fig. 2.
Voluta (Amoria) undulata. - Harris, 1897: 109.
Amoria (Amorena) undulata. – Ludbrook, 1953: 145, pl. 17, figs 3, 4 (holotype).
Amoria (Amorena) sclateri. – Ludbrook, 1953: 147, pl. 16, fig.7 (holotype).
Amoria (Amorena) undulata. – McMichael, 1964: 269.
Amoria (Amorena) benthalis McMichael, 1964: 271, pl. 28 lower figs.
Amoria (Amorena) benthalis. – Weaver and du Pont, 1970: 160, pl. 66H, 66I.
Amoria (Amorena) undulata. – Weaver and du Pont, 1970: 161, pl. 71A, 71B, 71C; Figs 33 d, e.

Description. Shell elongate ovate with conical spire. Protoconch of 3½ whorls. Spire whorls slightly concave. Body whorl depressed between posterior suture and shoulder and tapering gently from shoulder to anterior. Siphonal notch deep; siphonal fasciole not prominent.

Dimensions. Hypotype (P34267), L63, HA48, W32; Hypotype (P6593), L80, HA60, W38.

Location of types. Muséum d'Histoire Naturelle, Geneva: Holotype, Lamarck Collection No. 38, coll. F. Peron. National Museum of Victoria: Hypotype P34267, J. Dennant Collection; Hypotype P6593, coll. W. Kershaw.

Stratigraphic range. Late Miocene-Recent.

Occurrence. Fossil. Unnamed formation (Late Miocene), 55 m in bore on R. Hardy's property, Dalmore, FL111, Rose Hill; FL115, SE end of Lake Bunga; FL118, Ritchies Cutting; FL123 North Arm, below Ferndale Parade; FL129, Bentley Sewer; FL130, Beaumaris; FL148, E of Kalimna Jetty; FL149, Road cutting, Jemmys Point; FL151 Nyerimalang Estates Rd, Meringa Creek; FL158, Limestone Creek, Glenelg River. Flinders Is., Tas., Cameron Inlet Formation (Late Pliocene); Dam (58) on lot 47, Furneaux Estate Sect. B, 1.3 km due E of junction of No. 3 and No. 7 Rds (Flinders Is. 994657); spoil heap from North Patriarch drain on Block 6 Furneaux Estate A, 1.1 km from Link Rd (Flinders Is. 914741); Dam (64) on block 22 Furneaux Estate Sect. A, 4.3 km ENE of junction of No. 4 and No. 3 Rds (Flinders Is. 987733). Memana Formation (Early Pleistocene): Dam (5) on block 82, Furneaux Estate Sect. D, 2.6 km NNE of junction of No. 11 and No. 2A Rds (Flinders Is. 912814); Dam (6) on block 88, Furneaux Estate (Sect. D, 2.4 km ENE of junction of No. 11 and No. 2A Rds (Flinders Is. 915809). Roe Plain, WA, Roe Calcarenite (Early Pleistocene): 78 mile pit, N side Eyre Highway, 58.5 km E of Madura (Eucla, 1:250,000 369469); Pit 88 km W of Eucla Motel (Eucla, 1:250,000 406476); Pit 1.5 km N of Hampton Tower (Eucla, 1:250,000 365464).

Comments. This common species has been described in detail by both Ludbrook (1953) and Weaver and du Pont (1970), who have also provided extensive synonymies. However, *Voluta sclateri* Cox and its generally accepted synonym, *V. kingi* Cox, have been included in the author's synonymy, since the author regards these as mere colour variants of *A. undulata*. There are no differences in shell morphology which separate these taxa. *Amoria benthalis* McMichael is also included since it seems to be a dwarfed form of *A. undulata*, found in deep water at the extreme limit of the geographic range of *A. undulata*. Small specimens of the latter from Tasmania match specimens of *A. benthalis*. *Scaphella moslemica* Hedley is also based on a similar deep water form from 450 m off Sydney, as McMichael (1964) has indicated.

Fossil specimens from various localities also exhibit considerable size variation, but there is no systematic pattern, and all fossil populations fall

well within the range of variation of living specimens.

Some specimens from the Jemmys Point Formation, Cameron Inlet Formation, Memana Formation and Roe Calcarenite show colour pattern similar to that on living specimens.

Amoria exoptanda (Reeve)

Plate 29, figures 7, 10

Voluta exoptanda Reeve, 1849: pl. 10, species 22. G.B. Sowerby II, 1864: 271, pl. 261, fig. 136.

Voluta (Aulica) exoptanda. - Tryon, 1882: 91, pl. 26, fig. 72.

Aulica exoptanda. – Smith, 1942: 36, pl. 14, fig. 100

Amoria (Amorena) exoptanda. Weaver and du Pont, 1970: 160, pl. 66 F-G, Fig. 35.

Amoria exoptanda. – Wilson and Gillett, 1971: 124, pl. 81, fig. 5.

Description. Shell large, solid, ovate, with conical spire capped by large conical protoconch. Protoconch of 4 smooth whorls with slight shoulder producing a grooved suture. Teleoconch whorls sometimes slightly depressed at suture. Body whorl massive with prominent shoulder. Siphonal notch wide, siphonal fasciole not prominent. Colour pattern of thin, chestnut, zig-zag lines, closely spaced, covering whole shell, but leaving pale triangular patches.

Dimensions. Hypotype (WAM 79.394a) 188, HA65, W41.

Location of types. British Museum (Natural History): Holotype 1952.3.21.3, W.R. Crotch collection. Western Australian Museum: Hypotype 79.394a, coll. V.A Ryland, G.W. and W.F. Kendrick 5–13 Aug 1978.

Type locality. Port Lincoln, South Australia.

Stratigraphic range. Pleistocene–Recent.

Occurrence. Fossil, Roe Plain, WA, Roe Calcarenite: Foundation holes for Hampton Microwave Repeater Tower (Eucla, 1:250,000 365462); Pit 1.5 km N of Hampton Tower (Eucla, 1:250,000 365464).

Living, Esperance, WA–Encounter Bay, SA.

Material. 4 fossil and 5 living specimens.

Comments. This species is distinguished by its massive shell and large conical protoconch. Living specimens are quite rare and, hitherto, it has not been recorded as a fossil. The hypotype bears traces of the colour pattern typical of living specimens.

Amoria sp.

Comments. A single, poorly preserved and fragmentary specimen is available from the Middle Miocene, Trealla Limestone at Geological Survey of Western Australia locality 30055 on the E flank of Cape Range, Grid Ref. Onslow (1:250,000) 185260.

The specimen is a typical smooth *Amoria* but the preservation prevents any detailed comparison with any described species of the genus. It is mentioned here as the occurrence represents the oldest record of the genus in North Western Australia, equivalent in age to the oldest record for the south east of the continent.

Nannamoria Iredale, 1929

Nanamoria Iredale, 1929: 181. – Cotton and Godfrey, 1932: 48.

Amoria (Nannamoria). Wenz, 1943: 1339.

Nannamoria. McMichael, 1960: 11.

Paramoria McMichael, 1960: 12 (Type species (original designation): *Voluta guntheri* Smith, 1886)

Nannamoria. Weaver and du Pont, 1970: 170

Paramoria. Weaver and du Pont, 1970: 165.

Type species. Original designation: *Nannamoria amicula* Iredale, 1929. Recent, New South Wales.

Description. Shell solid, small to medium size, usually shouldered with subconical to gradate spire though spire often concealed by body whorl. Protoconch dome-shaped to pupiform, of $2\frac{1}{2}$–$3\frac{1}{2}$ smooth, convex whorls, coiled with axis of shell. Spiral sculpture poorly if at all developed. Axial sculpture generally well developed and consisting either of strong costae, usually spinose on shoulder, or of nodules which can be strongly or weakly developed. Aperture narrow, elongate, frequently slitlike. Outer lip slightly thickened. Columella with 4 strong plaits and often with 1 or more weaker plaits inserted between others. Siphonal notch usually scarcely developed; siphonal fasciole present but usually poorly developed.

Stratigraphic range. Late Oligocene–Recent.

Distribution. Southern Australia. Central Queensland New South Wales (Recent); Victoria (Late Oligocene–Late Miocene); Tasmania (Early Miocene, Late Pliocene); South Australia (Middle Miocene–Recent); Western Australia, south Coast (Pleistocene, Recent), west coast (Recent). 40–250 metres.

Comments. The relationships of the genus are with *Amoria*. The shell characters suggest affinity with *Notovoluta* and *Amoria* on the one hand and *Cymbiola* on the other. The anterior digestive system and radula of *N. strophodon guntheri* (Smith) have been examined by the author and no significant differences from species of *Amoria* were found. However the author (Darragh, 1979) has also examined the animals of *N. amicula* Iredale, the type species of the genus, and *N. inopinata* and

notes that whilst the anterior digestive system of both is similar to *N. strophodon guntheri*, the radulae are the typical uniserial tricuspid radulae found in many other volutes, e.g. in species of *Cymbiola*, rather than the Y-shaped radula of *Amoria*. Unfortunately the radula of *N. parabola* Garrard, which is closely related to *N. amicula*, is not known and it is not possible to determine whether this difference in radula is significant. In the genus *Scaphella* the radula morphology is quite variable within the various species, and it seems that *Nannamoria* presents a similar case, as there are no other features of the anatomy of *N. strophodon guntheri* and *N. amicula* which seem to differ. McMichael (1960) separated *Paramoria* and *Nannamoria* on the grounds that the former had a wide rather than slitlike aperture which was not produced posteriorly as in the latter, and by having four rather than several columella plaits and a larger protoconch. He further stated that the two had a distant common ancestry in the Tertiary. A study of the fossils shows that the above shell features not only vary considerably from species to species, but also from individual to individual within a species. In addition, some species such as *N. weldii* (Tenison Woods) can be readily placed in either *Paramoria* or *Nannamoria* as defined, depending on the particular specimen examined. Thus the author prefers to regard the two taxa as synonyms until further anatomical work proves otherwise.

Nothwithstanding the foregoing, three informal species groupings can be recognised, consisting of species lineages and taxa closely related to species within lineages. They are the group of *N. strophodon*, *N. weldii* and *N. ralphi* respectively and each group has at least one living representative. The species are described below in these groups.

The oldest known species of the genus is *N. weldii* (Tenison Woods) from the late Oligocene of Victoria and there is no known ancestral form in Australia. On the basis of shell characters and anatomy the genus may be derived from the early ancestors of *Cymbiola*.

Group One

Nannamoria stolida (Johnston)

Plate 7, figures 12–15
Plate 9, figures 2, 3

Voluta stolida Johnston, 1880: 36. – Johnston, 1888: pl. 30, figs 4, 4a.

Voluta strophodon var. *stolida*. – Pritchard, 1896: 94. – Pritchard, 1913: 194.

Paramoria stolida. – Ludbrook, 1967: 68, pl. 3, figs 9, 10.

Description. Shell ventricose with short, blunt, gradate spire. Protoconch slightly shouldered, smooth, of about 2½–3 rather swollen whorls which merge imperceptibly with teleconch whorls. Shoulder of whorls prominent, concave and smooth. First teleoconch whorl smooth, second and third with prominent spinose axial costae. Body whorl with 11–13 spinose axial costae which fade out anteriorly about half-way down whorl. Siphonal notch broad and shallow; siphonal fasciole moderately developed. Colour pattern of thin numerous close set axial stripes.

Dimensions. Holotype (Z186), L53, HA36, W29; Hypotype (P32910), L53, HA39, W31; P2534, L57, HA44, W32.

Location of types. Tasmanian Museum: Holotype Z186 R.M. Johnston Collection. National Museum of Victoria: Hypotype P32910, J. Dennant collection. Hypotype P2534, E.D. Atkinson Collection.

Type locality. "Table Cape". The preservation of the holotype indicates that it came from the lower bed, i.e., FL28, Lower bed in the cliff between Fossil Bluff and 1.5 km NW towards Table Cape, Wynyard, (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian, Early Miocene.

Occurrence. Type locality only.

Material. Holotype and 7 topotypes.

Comments. This species is probably ancestral to *N. strophodon* (McCoy) and is distinguished from it by its more ventricose appearance. The great swollen protoconch and overall appearance are similar to species of *Cymbiola*, but it lacks the prominent fasciole and deep siphonal notch present in species of *Cymbiola*.

Nannamoria strophodon strophodon (McCoy)

Plate 8, figures 1, 4, 5, 6, 9, 11

Voluta strophodon McCoy, 1876: 25, pl. 37, figs 2, 3, 4, 4a–c. – Tate, 1889b: 134.

Voluta (Aulica) strophodon. – Harris, 1897: 101, pl.4, figs 11a, b.

Vespertilio weldi. – Cossmann, 1899: 118, pl. 4, fig. 23, pl. 6, fig. 8.

Voluta strophodon var. *brevispira* Pritchard, 1913: 194 (non Doncieaux, 1908).

Voluta strophodon var. *longispira* Pritchard, 1913: 194.

Cymbiola strophodon. – Cotton, 1949: pl. 15.

Notovoluta tabulata. – Cotton, 1949: pl. 14 (non Tate, 1888).

Cymbiola (Cymbiola) tabulata. – Ludbrook, 1958: 74, pl. 6, fig. 2 (non Tate, 1888).

Description. Shell ovate to biconic with low, blunt, conical to gradate spire. Protoconch low, dome-shaped, of about 3 smooth whorls with impressed suture. Shoulder of teleconch whorls prominent and bearing 10–13 spinose tubercles on body whorl. Body whorl tapering gently to anterior. Columella with 4 plaits and often with well developed tubercle posterior to plaits. Siphonal notch shallow, siphonal fasciole present. Colour pattern of thin, close set, wavy, axial chestnut lines.

Dimensions. Holotype (P12154),L31, HA21, W16 (fig. 3 in McCoy, 1876, pl. 37); Paratype (P26388), L40, HA25, W19 (figs 4, 4b); Paratype (P26389), L40, HA26, W20 (figs 4a, c); Paratype (P12153), L32, HA25, W20 (fig. 2).

Location of types. National Museum of Victoria: Holotype P12154, coll. R. Daintree, Apr 1861; Paratype P26388, Paratype P26389, coll. R. Daintree, Aug 1861; Paratype P12153, Geological Survey of Victoria collection. McCoy's indication that fig. 3 was the average specimen and that the others figured were the conoidal and long-spired varieties is taken as designation of the holotype.

Type locality. FL38, Geological Survey of Victoria locality Ad 14, Section 24, block 1, Parish of Moolap, 2.4 km N of Curlewis railway crossing (Portarlington 823733). Fyansford Formation, Batesfordian.

Stratigraphic range. Batesfordian, Early Miocene–Yatalan, Late Pliocene.

Occurrence. FL38, Type locality; FL40, Belmont Shaft; FL47, Kennedys Creek; Fl48, Boornong Rd; FL67, 3.4 km NW of Point Ronald; FL69, Red Bluff, Shelford; FL71, SW of Glenleigh; FL72, Fyansford; FL74, Junction Rd. caisson shaft; FL77, Altona Bay Coal Shaft; FL78, Fossil Beach; FL82, Clifton Bank; FL84, 4 miles below Morgan; FL87, Lake Bullenmerri; FL88, NW end of Gibson Beach; FL89, VAL Quarry, Curdies; FL93, Rutledges Beach; FL97, Murgheboluc 2B; FL100, Murgheboluc 4A; FL103, downstream section Gunyoung Creek; FL104, Manyung Rocks; ? FL132, Spring Creek, Minhamite.

SA, Bookpurnong Beds, Cheltenhamian: Mindarie Well, S.A. Dry Creek Sands, Yatalan: Abattoires Bore; Observation Bore A, Virginia, Hd of Munno Para sec 3036, 63.7–66.1 m; H.K. Weymouths bore, 1935, Sec 2271, Hd of Yatala 94.5–99 m; Kooyonga bore no. 1, 1932, Hd of Adelaide, Sec. 2028, 119–146 m; F. Virgin bore, Mar 1958, Hd of Munno Para Sec. 3224 103–107 m; DeRuro bore, Waterloo Corner, Hd of Munno Para, Sec. 4259, 73.2–74.7 m; Jones bore, 1934, Bolivar, Hd of Port Adelaide, Sec. 3502, 106 m.

Material. Types, 2 topotypes and numerous other specimens.

Comments. This species exhibits considerable morphological variation from locality to locality, as is the case with many species of volute. Generally the Batesfordian and Bairnsdalian populations have lower spires than those of the Balcombian, but there is so much variation within these populations and others that Pritchard's names *brevispira* and *longispira* are not used subspecifically. Specimens from the Dry Creek Sands tend to have less gradate spires and larger and more sloping shoulders however, these features are not considered distinct enough to warrant subspecific separation of this population, particularly in view of the variation mentioned above. It seems probable that the living populations of *N. guntheri* (Smith) and *N. weaveri* (McMichael) also fall within the range of variation of *N. strophodon* but there is insufficient living material available at present to check this possibility. For the time being *N. weaveri* is regarded as a synonym of *N. guntheri* which is relegated to the status of a subspecies of *N. strophodon*. Of interest is the fact that the colour pattern of *N. strophodon* observed in Dry Creek Sands specimens and a single specimen from Muddy Creek is similar to that present in *N. guntheri*.

Nannamoria strophodon guntheri (E.A. Smith)

Plate 10, figure 4
Figure 13

Voluta guntheri E.A. Smith, 1886: 62. – G.B. Sowerby III, 1887: 302, pl. 17, figs 162, 163, holotype, Western Australia.

Voluta adcocki Tate, 1889a: 64, pl. 11, fig.

Paramoria guntheri. – McMichael, 1960: 11, pl. 1, fig. 5. – McMichael, 1961: pl. 5, lower figs.

Paramoria weaveri McMichael, 1961: 55, pl. 5, upper figs.

Paramoria guntheri guntheri. – Weaver and du Pont, 1970: 165, pl. 72A, B, C.

Paramoria guntheri weaveri. – Weaver and du Pont, 1970: 167, pl. 72D, E.

Comments. This species is the type of the genus *Paramoria* McMichael, 1960 and the reasons for placing the latter in the synonomy of *Nannamoria* have been discussed above. *Voluta adcocki* and *Paramoria weaveri* are regarded as being mere colour forms of the same species and accordingly are included in the above synonomy. Attention has been drawn above to the fact that the differences in morphology between *N. guntheri* and *N. strophodon* are slight, and for this reason the former has been relegated to the status of a subspecies of the latter.

The range of this taxon is from Houtman Abrolhos Islands, Western Australia to Encounter Bay, South Australia.

Nannamoria amplexa sp. nov.

Plate 7, figures 2, 3, 6
Plate 9, figures 9, 12
Plate 10, figure 12

Description. Shell biconical with low spire. Protoconch dome-shaped of 3½ smooth whorls, the last of which is partly hidden by first teleoconch whorl. Teleoconch whorls occasionally encroaching on previous whorls. Spire whorls convex at posterior suture and concave medially, usually axially costate and with row of spinose tubercles at anterior suture. Body whorl with prominent narrow shoulder, convex at suture and concave medially. Spiral sculpture absent. Axial sculpture on body whorl of 14–18 thin, poorly developed, irregularly spaced costae which extend from suture to fasciole and developed into spinose nodes on shoulder. Columella with 4 strong plaits. Siphonal notch shallow, siphonal fasciole weak and bordered posteriorly by thin, weak ridge.

Dimensions. Holotype (P33069), L37, HA29, W19; Paratype (P33071), L36, Ha27, W20; Paratype (P33072), L31, HA23, W19.

Location of types. National Museum of Victoria, Holotype P33069, Paratype P33071, Paratype P33072, coll. Mrs Coralie Griffiths, 1972–1973.

Type locality. FL123, Below high tide level, North Arm below Ferndale Parade, Lakes Entrance (Bairnsdale 867075). Jemmys Point Formation, Cheltenhamian.

Stratigraphic range. Mitchellian–Cheltenhamian, Late Miocene.

Occurrence. Upper quarry, Bellevue, left bank, Mitchell River; FL116, Ditch near L.E.D. No. 1 Bore; FL124, North Arm, north side, Hunter Gully.

Material. Types, 4 topotypes, and 3 other specimens.

Comments. This species is closely related to *N. strophodon*, but differs from the low spired specimens of that species by having weakly spinose nodules and weaker ribs which tend to cover the whole of the spire and body whorl. The fasciole is also bounded posteriorly by a weak ridge, which is a feature usually not well developed in *N. strophodon*.

Nannamoria lundeliusae Ludbrook

Plate 29, figures 8, 9
Plate 30, figures 5, 6

Nannamoria lundeliusae Ludbrook, 1978: 165, pl. 18, figs 20, 21.

Description. Shell elongate ovate with subconical spire. Protoconch subconical of 3 smooth whorls. Spire whorls with weakly developed shoulder, usually with axial sculpture but occasionally with low obsolete plicae. Body whorl gently tapering anteriorly from shoulder. Aperture narrow and elongate. Columella with 4 strong plaits. Siphonal notch deep; siphonal fasciole weakly developed. Colour pattern of thin, widely spaced, chestnut axial lines with 3 narrow spiral bands at suture, posterior and anterior third of body whorl.

Dimensions. Holotype (GSSA M2521) L48, HA31, W18; Paratype (WAM 72.26) L38, HA27, W16; Hypotype (WAM 76.2389a) L43, HA28, W18.

Location of types. Geological Survey of South Australia: Holotype M2521, Paratypes M3253. Geological Survey of Western Australia: Paratypes F6942, 7084. Western Australian Museum: Paratypes WAM 62.49, 66.622, 72.26, Hypotype WAM 76.2389a.

Type locality. Locality 4434-FL9, 64 km E of Madura (Eucla 575054), 31°53′42″S, 127°41′30″E. Roe Calcarenite, Early Pleistocene.

Stratigraphic range. Roe Calcarenite.

Occurrence Roe Calcarenite, various borrow pits along Eyre Highway and foundation holes for Hampton Microwave Tower, Roe Plain, Western Australia.

Material. 22 specimens.

Comments. On first glance this species could be placed in *Amoria* but because of the occasional presence of axial sculpture and the similarity of colour pattern to *N. strophodon* and *N. guntheri* it has been placed in *Nannamoria*. This species demonstrates the close affinity between *Amoria* and *Nannamoria*.

Group Two

Nannamoria weldii (Tenison Woods)

Plate 7, figures 5, 7
Plate 10, figures 1, 2

Voluta weldii Tenison Woods, 1876: 24, fig. 2. – Johnston, 1888: pl. 30, figs 6, 6a, b, 7. – Tate, 1889b: 134. – Pritchard, 1896: 93.

Voluta (Aulica) weldi (sic). – Harris, 1897: 102.

Voluta weldii. – Pritchard, 1913: 193, pl. 20, fig. 1.

Voluta weldii var. *angustior* Pritchard, 1913: 194, pl. 20, figs 4, 5.

Cymbiola weldii. – Cotton, 1949: 189, pl. 14.

Paramoria weldi. – Ludbrook, 1967: 68, pl. 3, figs 1, 2.

Description. Shell ventricose, elongate-ovate, occasionally biconical with elongate subconical spire. Protoconch smooth, dome-shaped, of 3 whorls. Spire whorls sometimes with weakly developed shoulder, but often without and bearing row of weakly developed tubercles against anterior suture

which become stronger towards body whorl. Body whorl bearing 8–10 prominent elongate tubercles on posterior third of whorl and narrowing rapidly and regularly anteriorly. Canal slightly reflexed dorsally; siphonal notch weak, siphonal fasciole well developed.

Dimensions. Holotype (Z191), L39, HA23, W23 (Upper bed); Hypotype (MUGD 1792), L40, HA22, W21 (Upper bed, Pritchard, 1913, pl. 20, fig. 1); MUGD 1794, L28, HA17, W13 (Lower bed, Pritchard, 1913, pl. 20, figs 4, 5).

Location of types. Tasmanian Museum: Holotype Z191. Melbourne University Geology Department: Hypotype MUGD 1792, Holotype of var. *angustior* MUGD 1794, G.B. Pritchard Collection.

Type locality. "Table Cape". The preservation of the holotype and the matrix inside its aperture indicates that it came from the upper bed, FL29, Fossil Bluff Sandstone in cliff between Fossil Bluff and 1.5 km NW towards Table Cape, Wynyard, Tas (Table Cape 930630). Janjukian, Lake Miocene.

Stratigraphic range. Janjukian, Late Oligocene–Longfordian, Early Miocene.

Occurrence. FL24, *Chione* beds opposite Bird Rock; FL28, Lower bed, Table Cape; FL29, Type locality; FL32, SW end of Jan Juc Beach; FL33, Birregurra.

Material. Holotype and 30 topotypes.

Comments. The narrow spire, prominent elongate nodules and biconical appearance distinguish this species from others in the genus. Specimens from the type locality are all of the typical ventricose biconical form, whereas those from the underlying "lower bed" tend to be more variable in morphology, with a narrow form the "var. *angustata* Pritchard" the most common. As a whole the population of the "lower bed" has more depressed and slightly larger protoconchs.

Nannamoria fasciculata sp. nov.

Plate 7, figure 10
Plate 10, figures 9, 11

Description. Shell elongate with subgradate spire and grooved sutures. Protoconch as in *N. weldii*. First teleoconch whorl flat, subsequent whorls with oblique shoulder. Spiral sculpture absent. Axial sculpture of spire of numerous irregularly spaced thin costae, which on shoulder are produced into small sharp nodes. On penultimate and final whorls costae become shorter and regularly spaced and on last half whorl reduced to spinose nodules or spinose plicae.

Dimensions. Holotype (P32915), L42, HA26, W17; Paratype (P32916), L40, HA24, W16; P32914, L45, HA27, W17.

Location of types. National Museum of Victoria: Holotype P32915, Paratype P32916, coll. T.A. Darragh and H.E. Wilkinson, 4 Dec 1968 and 14 Dec 1967 resp.

Type locality. FL35, cliff section SE of Fischers Point about 10 m above Lake Craven, Hordern Vale (Princetown 155040). Fishing Point Marl (lower mollusc horizon), Longfordian.

Stratigraphic range. Longfordian, Early Miocene.

Occurrence. FL34, Lake Costin, FL35, Type locality; FL36, Red Hill, Hordern Vale.

Material. Types 11 topotypes and 7 other specimens.

Comments. The numerous irregularly spaced costae and the high subgradate spire distinguish this species from other in the genus. It has evolved from *N. weldii* as specimens of the latter from Birregurra, a locality on a slightly older horizon, tend to have a similar sculpture but lack the high subgradate spire.

Nannamoria trionyma sp. nov.

Plate 11, figures 1, 4, 6, 7

Voluta weldii var. *intermedia* Pritchard, 1913: 194, pl. 20, figs 2, 3 (non Lahille, 1895: 304).

Description. Shell ovately elongate with low subgradate spire. Protoconch flat but with papillary nucleus. First teleoconch whorl bearing numerous axial plicae, which on second whorl develop into pointed trihedral nodules, of which there are 8–13 on body whorl and which fade out towards aperture. Spiral sculpture absent. Siphonal notch shallow; siphonal fasciole weakly developed.

Dimensions. Holotype (P32920), L36, HA23, W16; Paratype (P32918), L34, HA21, W16.

Location of types. National Museum of Victoria: Holotype P32920, F.S. Colliver Collection, Paratype P32918, coll. T.A. Darragh, 22 Oct 1971. Geology Department, University of Melbourne: Holotype of *Voluta weldii* var. *intermedia* MUGD 1793 G.B. Pritchard collection.

Type locality. FL82. Clifton Bank, Muddy Creek, 7 km W of Hamilton (Coleraine WD825219). Muddy Creek Formation, Balcombian.

Stratigraphic range. Balcombian, Middle Miocene.

Occurrence. FL69, Red Hill, Shelford; FL77, Altona Bay Coal Shaft; FL78 Fossil Beach; FL82, Type locality; FL84, 4 miles below Morgan.

Material. Types and 18 topotypes.

Comments. As Pritchard's varietial name is preoccupied by *Voluta colocynthus intermedia* Lahille, 1895 the taxon has been redescribed. It is derived from *N. weldii* and differs from it by having more numerous tubercles which tend to be subspinose,

and by having a squatter spire. *N. weldii* tends to be biconical in appearance whereas *N. trionyma* tends to be ovate.

Nannamora paraboloides sp. nov.

Plate 9, figures 6, 7
Plate 10, figures 7, 8
Plate 11, figures 2, 3

Description. Shell ovate with low subconical spire. Protoconch pupiform of 2½–3 smooth convex whorls. Whorls slightly to prominently shouldered, concave posterior to shoulder. Anterior whorls almost overlapping shoulder so that anterior whorl slope of spire is much reduced or even absent. Sculpture of low nodes or axial plicae on shoulder which vary in strength and generally fade out towards aperture. Usually 10–12 nodes present on body whorl. Columella with 4 strong plaits. Siphonal notch deep; siphonal fasciole well marked. Canal slightly reflexed dorsally. Traces of colour pattern present consisting of triangular tent-like markings.

Dimensions. Holotype (P33077), L29, HA21, W14; Paratype (P33079), L28, HA20, W15; Paratype (P52308), L 42, HA30, W25.

Location of types. National Museum of Victoria: Holotype P33077, coll. T.A. Darragh and M. Waldman, 1967. Paratype P33079, coll. T.A. Darragh, D.M. Shanks and H.E. Wilkinson, 6 Feb 1969. Paratype P52308, coll. T.A. Darragh, 14 Feb 1978.

Type locality. FL132, bed of Spring Creek below "tuff" band, 0.8 km NE of Spring Creek Homestead, Minhamite (Hawkesdale 367129).

Stratigraphic range. Cheltenhamian, Late Miocene–Late Pliocene.

Occurrence. FL111, Rose Hill; FL132, Type locality; FL141, SW side, Bunga Creek, FL142, bed 6g, NE side Bunga Creek; FL151, Nyerimalang Estates Rd, Meringa Creek; Tas, Cameron Inlet Formation (Late Pliocene); PL1234, Dam an addition to Lot 37, Memana; PL1258, Dam on lot 47, Memana; PL1264, Dam on lot 22, Memana; PL1265, Dam on lot 22, Memana; PL 1268, Patriarch drain at Block 6, Memana. Jemmys Point Formation (Cheltenhamian): 175–185 ft Tanjil Point Addis No. 2 Bore.

Material. Types, 4 topotypes and numerous specimens from Flinders Is.

Comments. In general outline this species resembles *N. parabola* Garrard but the generally feeble sculpture and subconical spire distinguish it from that species.

Nannamoria amicula Iredale

Figure 14

Nannamoria amicula Iredale, 1929: 181, pl. 40, fig. 4. – Weaver and du Pont, 1970: 170, pl. 73A and B. – Wilson and Gillett, 1971: 132, Fig. 26 (holotype).

Comments. Weaver and du Pont (1970) have given good figures and descriptions of this and the following species. *N. amicula* ranges from southern to northern New South Wales.

Nannamoria parabola Garrard

Nannamoria parabola Garrard, 1960: 3, pl. 1, figs 1A, 1B.

Nannamoria parabola. – Weaver and du Pont, 1970: 171, pl. 73E, F.

Comments. The species is restricted to vicinity of Moreton Island, southern Queensland.

Group Three

Nannamoria deplexa sp. nov.

Plate 7, figures 1, 4
Plate 10, figures 5, 6
Plate 11, figures 5, 8

Description. Shell pyriform, ventricose with low blunt spire. Protoconch of 2½–3 whorls, somewhat flattened and with papillary nucleus; last whorl of protoconch and first teleoconch whorl enveloped by succeeding whorls. Spire whorls inflated. Body whorl inflated against suture and tapering rapidly to anterior. Spiral sculpture of microscopic close-set wavy grooves confined to spire and posterior quarter of body whorl. Aperture long and narrow. Columella covered with thin glaze and bearing 4 strong plaits and rarely 1 or 2 weaker plaits inserted between others. Siphonal notch and siphonal fasciole barely developed.

Dimensions. Holotype (P32922), L32, HA23, W15; Paratype (P32923), L32, HA21, W17; Paratype (P32924), L27, HA20, W16.

Location of types. National Museum of Victoria: Holotype P32922, Paratype P32923, Paratype P32924, coll. T.A. Darragh and H.E. Wilkinson, 27 Dec 1969.

Type locality. FL48, Cutting on Boornong (= Steen) Rd, 2.1 km N of Cooriemungle Rd, Cooriemungle (Princetown 810337) Gellibrand Marl, Batesfordian.

Stratigraphic range. Batesfordian, Early Miocene.

Occurrence. FL39, Ad 12, Curlewis; FL40, Belmont Shaft; FL41 Amphitheatre; FL42, Yarrowee R, S of Amphitheatre; FL47, Kennedys Creek Cutting; FL48, Type locality; FL50, Fischers Point, FL51 Devils Den, Glenelg R; PL3163, Williams Rd, Cowleys Creek.

Material. Types and 22 topotypes.

Comments. This species is ancestral to *N. ralphi* (Finlay) and differs in having a more ventricose body whorl and a less prominent spire, the protoconch also is not pupiform but low and broad and there are rarely any visible nodulae on the body whorl as in *N. ralphi*.

Nannamoria ralphi (Finlay)

Plate 9, figures 1, 4, 5, 8
Plate 10, figure 3

Voluta (Volutoconus) conoidea Tate, 1888: 176, pl. 13, fig. 9 (non Renier, 1804).

Voluta conoidea. – Tate, 1889b: 125 (description).

Voluta (Volutoconus) conoidea. – Harris, 1897: 107, pl. 4, figs 13a, b.

Volutoconus conoideus. – Cossmann, 1899: 131, pl. 7, fig. 3.

Volutoconus ralphi Finlay, 1930: 44. – Cotton, 1949: pl. 15.

Description. Shell biconic with moderately short, blunt spire. Protoconch as in *N. limbata*. Spire whorls partly concealed by suceeding whorls. Body whorl bearing 5–7 low nodules at posterior third, but these frequently absent. Posterior whorl slope sculptured as in *N. limbata*. Aperture long and narrow. Siphonal notch and siphonal fasciole barely developed.

Dimensions. Holotype (T588A), L44, HA30, W21; Hypotype (P33074), L36, HA27, W16; Hypotype (P33076), L35, HA26, W16.

Location of types. South Australian Museum: Holotype T588A, R.Tate Collection. National Museum of Victoria: Hypotype P33074, Mrs M. Robertson Collection; Hypotype P33076, G.B. Pritchard Collection.

Type locality. Lower beds, Muddy Creek, i.e., FL82 Clifton Bank, Muddy Creek, near Hamilton (Coleraine WD820224). Muddy Creek Formation, Balcombian.

Stratigraphic range. Balcombian, Middle Micoene.

Occurrence. FL72, Fyansford; FL77, Altona Bay coal shaft; FL82, Type locality.

Material. Holotype and 17 topotypes.

Comments. This taxon is derived from *N. deplexa* sp. nov. and is ancestral to *N. limbata* (Tate). Compared with the latter it has fewer nodules, is not as variable in morphology and has no lamellar extensions covering the suture of the spire whorls. It has been compared with *N. deplexa* under the description of that taxon.

Traditionally, this taxon and *N. limbata* have been placed in the genus *Volutoconus*, however the species in that genus have deep narrow siphonal notches, prominent siphonal fascioles and multispiral, ribbed, planorbid protoconchs with an exert tip.

Nannamoria limbata (Tate)

Plate 7, figures 8, 9, 11
Plate 9, figures 10, 11
Figure 12

Voluta (Volutoconus) limbata Tate, 1888: 176, pl. 13, fig. 8 (figure).

Voluta limbata. – Tate, 1889b: 125 (description).

Volutoconus limbata. – Cotton, 1949: pl. 15.

Description. Shell usually subcylindrical with short and often concealed spire, occasionally elongate biconic with high conical spire. Protoconch pupiform of 2½–3 whorls, last of which axially costulate and usually covered by lamella extension of following teleoconch whorl. Sutures and spire generally concealed by lamella extension of final or penultimate whorl. Body whorl gently convex and bearing at posterior third row of 6–10 weak nodules which tend to fade in strength towards aperture. Posterior whorl slope sculptured with numerous, close-set spiral grooves. Aperture narrowly elongate. Columella covered with thick glaze and bearing 4 strong and rarely 1 or 2 other weaker plaits inserted between others. Siphonal notch barely developed; siphonal fasciole present but not prominent. Visible colour pattern of 4 thick, alternate light and dark spiral bands.

Dimensions. Holotype (T590A), L33, HA23, W16; Hypotype (P33086), L42, HA36, W18; Hypotype (P33088), L39, HA26, W17.

Location of types. South Australian Museum: Holotype T590A, R. Tate Collection. National Museum of Victoria: Hypotype P33086, Hypotype P33088, F.A. Cudmore Collection.

Type locality. "Schnapper Point". As no specimens of this species have been found at Fossil Beach 3.2 km S of Schnapper Point, Mornington, Tate's type must have been collected from exposures of Balcombe Clay in the vicinity of Gunyoung (Grices) Creek, 3.2 km NE of Schnapper Point. The preservation of the holotype including the presence of colour bands, is typically that found in specimens from Gunyoung Creek or Manyung Rocks. Accordingly, the latter locality is herein designated the type locality. Cliff section immediately south of Manyung Rocks and N of the jetty and sewer pipe, bed 10Ba (Western Port 309712). Upper Balcombe Clay, Bairnsdale.

Stratigraphic range. Bairnsdalian.

Occurrence. FL87, Lake Bullenmerri, FL88, NW end of Gibson Beach; FL89, Curdies; FL93, Rutledges Beach; FL96 Leigh River due north of Inverleigh; FL103,

Lower–Upper beds Grices Creek; FL104 type locality. Leigh R at Inverleigh bridge; Grange Burn 1.2 km above Hentys.

Material. Holotype and 13 topotypes.

Comments. This is an exceedingly variable species. Specimens from Lake Bullenmerri generally have high spires and prominent nodulose shoulders, but other members of this population are similar to those found at the type locality. The colour bands preserved in some specimens are similarly placed to those found in *N. parabola* Garrard and *N. inopinata* Darragh.

Nannamoria cinctuta sp. nov.

Plate 11, figures 9–12

Description. Shell obconical with low and rapidly tapering spire. Protoconch pupiform of 2½–3 smooth whorls. Spire whorls almost covered by succeeding whorls. Suture somewhat channelled. Body whorl convex and tapering gently anteriorly. Spiral sculpture absent. Axial sculpture of weak plicae on spire and low elongate nodules sometimes present on body whorl. Columella with 4 strong plaits.

Dimensions. Holotype (P33081), L48, HA34, W23; Paratype (P33082), L47, HA36, W24.

Location of types. National Museum of Victoria: Holotype P33081, Paratype P33082, coll. T.A. Darragh, D.M. Shanks and H.E. Wilkinson, 10 Feb 1969.

Type locality. Tas, PL 1264, Dam on Block 22 (Lees), Furneaux Sect. A, 4.4 km ENE of junction of No. 4 and No. 3 Roads, Memana (Flinders Is. 987733). Cameron Inlet Formation, Late Pliocene.

Stratigraphic range. Late Pliocene.

Occurrence. Type locality only.

Material. Types and 6 topotypes.

Comments. This species resembles *N. ralphi* but has flat rather than prominently convex spire whorls and a low rather insignificant spire. *N. limbata* has prominent spiral sculpture and the body whorl is not as ventricose.

Nannamoria capricornea (Wilson)

Plate 8, figures 2, 3, 10

Volutoconus capricorneus Wilson, 1972: 346, pl. 31, figs 9–12.

Comments. Wilson (1972) has given a good description and figure of this species and discussed its affinities in detail. He assigned it provisionally to *Volutoconus* because of its close resemblance to *Nannamoria limbata* and *N. ralphi*, which were at that time regarded as species of *Volutoconus*. The writer regards these latter as species of *Nannamoria* and accordingly, after examination of the paratype, also places *V. capricorneus* in that genus. Of the two fossils mentioned above the living species most closely resembles *N. ralphi* but differs in having a wider and blunter spire and is ovate in outline rather than biconical as in *N. ralphi*. Neither the radula nor anatomy of this species is yet known, so it is not possible to confirm its relationship with the other living species of *Nannamoria*.

Nannamoria inopinata Darragh

Plate 27, figures 12, 13

Nannamoria inopinata Darragh, 1979: 133, figs 1–3, 5, 6, 12.

Description. Shell biconic to subcylindrical with short, blunt, almost domelike spire. Protoconch of 3 dome-like whorls, coiled in axis of spire. Spire whorls convex, partly concealed by overlapping of succeeding whorls and occasionally bearing small spinose nodules at anterior suture. Body whorl gently convex and tapering anteriorly, bearing at posterior quarter row of 8–10 blunt to subspinose nodules. Spiral and axial sculpture absent. Columella with 5 strong plaits and 3 or 4 other weaker plaits inserted between others. Siphonal notch and fasciole barely developed. Colour pattern of numerous thin, anastomosing, axial, chestnut lines, over whole shell, and on body whorl 2 dark reddish bands at posterior and anterior third of whorl.

Animal very similar to that of *N. amicula*. Foot broad, flat, entire; siphonal appendages short, paired and equal; tubular salivary gland of digestive system, short, paired and easily separated from racemose salivary gland. Radula uniserial, tricuspid with central tooth the larger.

Dimensions. Holotype (C108644a), L48, HA41, W20; Paratype (C108644b), L39, HA–, W17; Paratype (C109012), L40, HA34, W17.

Location of types. Australian Museum: Holotype C108644a, Paratype C108644b, coll. W.F. Ponder, I. Loch and P. Terrill, 14 Dec 1977; Paratype C109012, coll. P. Colman and F. Rowe, 17 Nov 1977.

Type locality. Capricorn Channel, 42 km NE of Lady Musgrave Is, Queensland (23°38.8′S, 152°45.5′E), 365 m, 1977 HMAS "Kimbla" Cruise Station 24, 14 Dec 1977.

Occurrence. 40 km E of Lady Musgrave Is, Qld (24°44′S, 152°49′E), 348–357 m, shelly grey ooze, 1977 HMAS "Kimbla" Cruise Station 2, 17 Nov 1977. 39 km E of Lady Musgrave Is, Qld (23°33.7′S, 152°37′E), 348–339 m, 1977 HMAS "Kimbla" Cruise Station 3, 17 Nov 1977. E of North West Is, Capricon Channel, QLD (23°19.5′S, 152°35.4′E), 320 m, globigerine mud, 1977 HMAS

"Kimbla" Cruise Station 23, 14 Dec 1977.

Material. Types, 2 adults and 4 juvenile specimens and 6 fragments.

Comments. This species most closely resembles the Middle Miocene *N. limbata* (Tate) from Victoria from which it differs by the dome-like, rather than pupiform protoconch, by the complete absence of spiral sculpture and the lack of lamella extension of the posterior part of the whorls, typical of the latter. From *N. ralphi* (Finlay) it differs by its more slender and elongate shape and relatively low spire. The dark spiral bands of the colour pattern are somewhat similar to those preserved on *N. limbata.* Neither *N. ralphi* nor N. limbata have the subspinose nodules as sharply developed as in *N. inopinata.* Of the living species of the genus, *N. parabola* Garrard from Southern Queensland and Northern New South Wales has a similar colour pattern, but is half the size with a gradate spire and prominent spinose shoulders. *N. capricornia* (Wilson) from Western Australia, has a more conical spire, is two-thirds the size, has no subspinose nodules and lacks any linear type colour pattern. This latter species also lacks spiral sculpture.

Zidoninae H. and A. Adams, 1853

(= Alcithoinae Pilsbry and Olsson, 1954)

Diagnosis. Head broad, flat, undivided with short flat tentacles. Siphon with 2 equal to subequal appendages. Operculum absent. Tubular salivary gland of anterior digestive system very long and easily separated from racemose salivary gland. Gland of Leiblein large, convoluted and easily separated from the oesophagus. Radula uniserial with tricuspid rachidian, central cusp of which usually the larger.

Remarks. The grouping of genera within the subfamily is based on studies of the taxa listed in Appendix 2. In addition to those South American and New Zealand genera included in the subfamily by Pilsbry and Olsson (1954), Clench and Turner (1964) and Weaver and du Pont (1970) there are added the Australian genera *Cymbiola* and *Melo,* previously included by those authors in the Cymbiinae, and *Ericusa and Livonia,* previously included in the Fulgorarinae. The anatomy and radulae of species of these genera have been examined and, since they agree in all respects with those described by Clench and Turner (1964) for the Zidoninae, these genera are included here. *Notopeplum,* overlooked by Pilsbry and Olsson (1954), was placed in the Scaphellinae by Weaver and du Pont (1970), presumably on the basis of shell characters as the soft parts were not known. Subsequently Wilson (1972) described the anatomy and radula which are similar to that of *Ericusa* and for that reason the genus is placed in the Zidoninae. Other non-Australian genera included in the subfamily here on the basis of radula and anatomy are *Guivillia* (Knudson, 1973) *Harpovoluta* (Eales, 1923) and *Miomelon* (Stuardo and Villorreal, 1974). The other genera, including those known only as fossils, are included on the basis of their affinity with genera having living species whose systematic position is known.

The number of New Zealand genera seems out of proportion when compared with those of other regions, but may well be reduced in the light of a modern revision.

The taxa included in the subfamily by the writer are as follows:

Zidona H. and A. Adams, 1853 (see Clench and Turner, 1964);

Adelomelon Dall 1906 (= *Janithoe* Pilsbry and Olsson, 1954);

A. (Weaveria) Clench and Turner, 1964;

A. (Pachycymbiola) Ihering, 1907;

Miomelon Dall, 1907 (see Stuardo and Villoreal, 1974);

Proscaphella Ihering, 1907;

Guivillea Watson, 1886 (see Knudson, 1973);

Harpovoluta Thiele, 1912 (Eales, 1923);

Alcithoe H. and A. Adams, 1853 (= *Leporemax* Iredale, 1937;

Palomelon finlay, 1926, *Caroluta* Iredale, 1937, *Gilvostia* Iredale, 1937) (see Ponder, 1970);

A. (Waihoaia) Marwick, 1926;

Pachymelon Marwick, 1926 (= *Palomelon* Finlay, 1926);

Iredalina Finlay, 1926;

Mauira Marwick, 1943;

Mauithoe Finlay, 1930;

Teremelon Marwick, 1926;

Metamelon Marwick, 1926;

Spinomelon Marwick, 1926;

Ericusa H. and A. Adams, 1858 (= *Mesericusa* Iredale, 1929);

Livonia Gray, 1855 (= *Mamillana* Crosse, 1871; *Pterospira* Harris, 1897; *Cottonia* Iredale, 1934);

Notopeplum Finlay, 1927 (see Wilson, 1972);

Sigaluta Rehder, 1967 (possibly a synonym of *Notopeplum);*

Melo Broderip in Sowerby, 1826 (= *Melocorona* Pilsbry and Olsson, 1954);

Cymbiola Swainson, 1831 (= *Aulica* Gray, 1847, *Aulicina* Roverato, 1899, *Cymbiolacca* Iredale, 1929, *Cymbiolena* Iredale, 1929).

The distribution of representatives of this sub-

family through the Tertiary and in present seas is principally Southern Hemisphere, in fact circum-Antarctic with two main northern extensions through South America and through Australia, New Zealand, Indonesia and the Philippines. The present distribution closely mirrors that of the Subfamily in the Tertiary. The origin of most genera is not clear as the American genera appear in the Miocene without earlier Tertiary ancestors, however, they seem to have close affinity with the New Zealand and Australian genera some of which appear in the Eocene.

In the Australian Tertiary the subfamily is represented by *Alcithoe, Ericusa, Livonia, Notopeplum and Cymbiola* of which the last four and *Melo* occur in the living fauna. *Melo* is known from the Pliocene of Indonesia, doubtfully from the Middle Miocene of north-western Australia, but not from the Tertiary of south-eastern Australia.

Alcithoe H. and A. Adams

Alcithoe (Waihaoia) Marwick

Waihaoia Marwick, 1926: 270, 274.

Type species. Original designation: *Waihaoia allani* Marwick, 1926. Eocene, McCullough's Bridge, New Zealand.

Description. Shell of small to medium size, fusiform, very elongate, somewhat contracted anteriorly and with high spire. Protoconch of 1½-2 smooth whorls, generally coiled with axis of shell, occasionally with small spike or calcarella on initial whorl. Prominent shoulder on body whorl and often on spire whorls. Axial sculpture of coarse ribs usually well developed and frequently with nodules at shoulder of whorl. Spiral sculpture of small threads but frequently absent. Aperture narrow, elongate with slightly reflexed outer lip. Columella with 4 and sometimes 5 strong plaits. Siphonal notch very shallow and siphonal fasciole not well developed or absent.

Stratigraphic range. Middle Eocene–Late Miocene.

Distribution. New Zealand, North and South Islands (Middle Eocene–Late Miocene).

Australia. Victoria, (Late Eocene–Middle Miocene); South Australia (Late Eocene, Middle Miocene); Tasmania (Early Miocene).

Comments. The very elongate appearance and the well developed costae are the characteristic features of this taxon. It is differentiated from *Alcithoe* s.s. by the presence of a shallow siphonal notch, and by the fasciole, which is not marked off posteriorly by a thin ridge, but is either a raised cord, or is sometimes absent. According to Finlay (1930) only *Spinomelon* and *Metamelon* have a strongly spiked protoconch, however, well preserved topotypes of *Waihaoia allani* the type species of *Waihaoia* do show this feature (see Figure 16), thus it has little or no significance as a generic feature. Both *A. (W.) sarissa* (Tate) (Early–Middle Miocene, Australia) and *A. (W). rugosa* Marwick (Late Miocene, New Zealand) have reasonably well developed siphonal fascioles which seems to indicate that this feature developed in species towards the end of the range of the genus.

Waihaoia has a rather similar range in time in both Australia and New Zealand. It appears a little earlier (Middle Eocene) in New Zealand but there are no suitably fossiliferous Middle Eocene sediments known in Australia. It is absent from the Australian Late Miocene but does survive into the Late Miocene in New Zealand. There are no known Australian offshoots or descendants from the genus, whereas Marwick (1926) has indicated possible offshoots in the New Zealand Tertiary.

In the Tertiary of south-eastern Australia there are six species in the subgenus, of these three *A. (W.) tateana* (Johnston), *A. (W.) pueblensis* (Pritchard) and *A. (W.) sarissa* (Tate) form a group of closely related species and the others are perhaps more closely related to New Zealand species rather than to any other Australian species.

Cotton (1949) placed the above three species and *Voluta cribrosa* Tate in the genus *Notovoluta,* but they do not possess the regularly coiled, dome-shaped, multispiral protoconch characteristic of species of that genus.

Alcithoe (Waihaoia) cribrosa (Tate)

Plate 13, figures 1–4

Voluta cribrosa Tate, 1889b: 129, pl. 3, fig. 8.

Description. Shell fusiform with moderately high spire. Protoconch with impressed suture, of 2 smooth whorls, first of which swollen with erect initial portion, and second flattened, passing somewhat abruptly into sculptured teleoconch whorls. Teleoconch whorls slightly depressed at posterior suture and slightly convex anteriorly. Body whorl with weak shoulder. Spiral sculpture of thin, close-set threads, present over whole of spire and body whorls. Axial sculpture of low, but sharp, well spaced costae, extending from suture to suture on spire, but obsolete on shoulder of body whorl and becoming weaker and finally absent towards aperture. Columella with 4 plaits, of which anterior is weakest. Siphonal notch broad and shallow; siphonal fasciole not developed.

Dimensions. Lectotype, specimen crushed (T605A), L34, HA–, W–; Hypotype, specimen crushed, (P34824), L51, HA29, W17 est.; Hypotype, (FL14) (P34825), L57, HA30, W20.

Location of types. South Australian Museum: Lectotype T605A (Tate's figured specimen selected herein); paralectotypes T605B–D, R. Tate Collection. National Museum of Victoria; Hypotype P34824, coll. T.A. Darragh, 30 Oct. 1971; Hypotype P34825, coll. T. Hughes, 29 Nov 1972.

Type locality. "*Turritella* clays" Blanche Point, Aldinga Bay (Noarlunga 689963). Blanche Point Marl, Aldingan. Late Eocene.

Stratigraphic range. Aldingan, Late Eocene.

Occurrence. FL10, Type locality; FL14, BC III washout nearest Johanna River; FL19, Point Flinders.

Material. Types and 4 topotypes.

Comments. There are no close relatives of this species in the Australian Tertiary, but it bears some resemblance to the New Zealand Bortonian *Waihaoia striata* Laws, from which it differs by having stronger sculpture and being less elongate.

Alcithoe (Waihaoia) pagodoides pagodoides (Tate)

Plate 12, figures 1, 4, 7, 10, 13
Figure 17

Voluta pagodoides Tate, 1888: 176, pl. 13, fig. 7 (figure).
Voluta pagodoides. – Tate, 1889b: 132 (description).
Scaphella (Eopsephia) pagodoides. – Harris, 1897: 117.
?Notovoluta pagodoides. – Cotton, 1949: pl. 14
Notovoluta pagodoides. – Ludbrook, 1969: Fig. 96-3. – Ludbrook, 1973: pl. 25, figs 34, 35.

Description. Shell elongate, fusiform with slender turreted spire bearing median row of tubercles. Protoconch of 2 smooth convex whorls with impressed suture and coiled with axis of shell. First teleoconch whorl bearing thin longitudinal ribs which develop into median row of sharp tubercles on subsequent whorls. Body whorl bearing 9–10 tubercles on posterior third of whorl. Spiral sculpture of fine threads present on first 2 or 3 teleoconch whorls. Columella with 4 strong plaits and occasionally weaker posterior fifth plait. Canal reflexed dorsally. Siphonal notch shallow; siphonal fasciole a weak cord.

Dimensions. Holotype (T610B), L50, HA27, W17; Hypotype (P34821), L40, HA23, W17; Hypotype, FL11 (P34822), L52, HA27, W16.

Location of types. South Australian Museum: Holotype T610B, R. Tate Collection. National Museum of Victoria: Hypotype P34821, F.S. Colliver Collection, Hypotype P34822, coll. K. Bell and T.A. Darragh, 25 Feb 1970.

Type locality. The holotype is labelled "fig. 7 Kent Town bore" but the explanation of the original figure states the locality as Aldinga. The matrix within the aperture is typical Blanche Point Marl from Blanche Point, Aldinga Bay, rather than the dark clayey greensand of the bore.

Stratigraphic range. Aldingan, Late Eocene–Early Janjukian, late Oligocene.

Occurrence. South Australia. Blanche Point Marl: FL10, Type locality; Adelaide bore, Kent Town Waterworks; 25 m, bore 240 (G. Heading), Sect. 261. Hd of Yatala, Klemzig; Ardrossan. Buccleuch Group: 15 m coal bore, Moorlands.

Victoria. FL11, BC1, washout nearest Brown Creek; FL19, Point Flinders; FL22, Addiscot Beach.

Material. Type and 8 topotypes.

Comments. This taxon is characterised by the general absence or poor development of spiral sculpture and the presence of shoulder tubercles. There is some variability in the degree of elongation of the spire and development of the shoulder tubercles. Victorian specimens tend to be more elongate and have more prominent tubercles than specimens from South Australia, though there is sufficient overlap in morphology between the two groups to maintain them in the same subspecies. Of the New Zealand species of the genus it bears the closest resemblance to *A. (W.) suteri* Marwick and *A. (W.) thomsoni* Marwick but lacks the prominent axial costae characteristic of these species.

Alcithoe (Waihaoia) pagodoides sororcula
subsp. nov.

Plate 12, figures 2, 3, 6, 8

Description. Shell small elongate, fusiform with slender turreted spire bearing median row of sharp tubercles. Protoconch as in *A. (W.) pagodoides pagodoides*. Body whorl bearing 8–11 small sharp tubercles. Spiral sculpture consisting of close-set threadlets present over whole surface of spire and body whorls. Columella with 4 strong plaits and occasional weaker plait inserted between others. Siphonal notch very shallow; siphonal fasciole scarcely developed.

Dimensions. Holotype (P37630), L38, HA19, W12; Paratype (P37631), L33, HA18, W12.

Location of types. National museum of Victoria. Holotype P37630, Paratype P37631, J. Dennant Collection.

Type locality. FL24, Bird Rock Cliffs, Torquay (Torquay 642518). Jan Juc Formation, Janjukian.

Stratigraphic range. Janjukian, Late Oligocene.

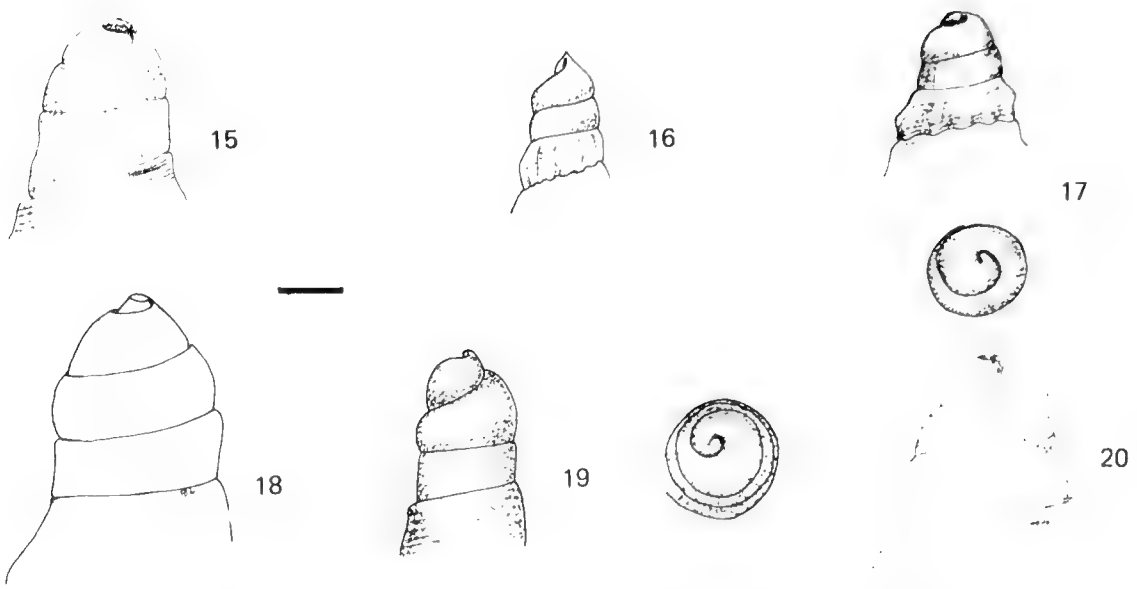

Figure 15. *Alcithoe (Waihaoia) pueblensis* (Pritchard), MUGD 1806, holotype, Bird Rock Cliffs.
Figure 16. *Alcithoe (Waihaoia) allani* (Marwick), GS 9508, McCulloughs Bridge, New Zealand.
Figure 17. *Alcithoe (Waihaoia) pagodoides pagodoides* (Tate), P34821, hypotype, Blanche Point, SA.
Figure 18. *Alcithoe (Alcithoe) macrocephala* (Finlay), SAM P5755, hypotype, "Murray Plains".
Figure 19. *Alcithoe (Waihaoia) sarissa* (Tate), P38301, hypotype, Clifton Bank, Muddy Creek.
Figure 20. *Alcithoe (Alcithoe) orphanata* sp. nov., P37635, holotype, Flinders Is., Tas. (scale = 2 mm)

Occurrence. FL24, Type locality; FL26, Barwon River S of Birregurra.

Material. Types and 30 topotypes.

Comments. This subspecies has been separated from *A. (W.) pagodoides pagodoides* (Tate) on the basis of its spiral sculpture, which consists of fine close set threads covering the entire surface of the shell. In *A. (W.) pagodoides pagodoides* the spiral sculpture, if at all present, is merely confined to the first one or two teleoconch whorls. It is generally much larger in size.

Alcithoe (Waihaoia) neglectoides sp. nov.

Plate 12, figures 5, 9, 11, 12

Description. Shell elongately fusiform with narrow turriculate spire. Protoconch of 1½–2 convex whorls somewhat flattened on top. Spire whorls flat to gently convex. Spiral sculpture of numerous close-set threads covering whole of spire whorls and body whorl. Axial sculpture of sharp tubercles which are occasionally present on penultimate whorl but usually only on body whorl. Body whorl with 9–12 tubercles on posterior third of whorl. Columella with 4 strong plaits, weak posterior fifth plait and rarely other weaker plaits present. Canal reflected dorsally. Siphonal notch shallow; siphonal fasciole a weakly developed cord. Colour pattern of thin widely spaced zigzag lines.

Dimensions. Holotype (P37628), L45, HA29, W16; Paratype (P37627), L37, HA22, W13.

Location of types. National Museum of Victoria. Holotype P37628, F.A. Cudmore collection; Paratype P37627, F.S. Colliver collection.

Type locality. FL24, Cliff section below Bird Rock cap, Bird Rock Cliffs, Torquay (Torquay 642518). Jan Juc Formation, Janjukian.

Stratigraphic range. Janjukian, Late Oligocene.

Occurrence. Type locality only.

Material. Types and 14 topotypes.

Comments. This species has been confused with *A. (W.) pagodoides*, however it differs in having a gently tapering spire of relatively flat whorls and lacks nodules on the spire whorls. It bears a strong resemblance to the New Zealand Early Miocene species, *Alcithoe neglecta* Marwick, but is generally more elongate and has fewer tubercles on the body whorl. The siphonal notch and fasciole are not as well developed as in typical *Alcithoe* and for this reason the species is retained in the subgenus *Waihaoia* pending a revision of the New Zealand volute genera.

Alcithoe (Waihaoia) pueblensis (Pritchard)

Plate 14, figures 1–3, 8–10
Figure 15

Voluta pueblensis Pritchard, 1898: 109, pl. 8, fig. 7.

Description. Shell fusiform, elongate with acute spire and weakly shouldered body whorl. Protoconch somewhat conical of 2½ smooth rather flattened whorls and coiled with axis of shell. Initial teleoconch whorls flat but becoming shouldered with development of thin axial costae. On body whorl there are 9–12 costae which extend anteriorly from shoulder to about midpoint of whorl and then become obsolete. Spiral sculpture of threads confined to spire whorls and posterior third of body whorl. Columella with 4 strong plaits; siphonal notch broad and shallow; siphonal fasciole poorly developed.

Dimensions. Holotype (MUGD 1806), L 57, HA32, W19; Hypotype (P34842), L 53, HA29, W17; Hypotype (P12773), L 75, HA43, W24.

Location of types. Melbourne University Geology Department: Holotype MUGD 1806, purchased G.B. Pritchard, 11 Oct 1939. National Museum of Victoria. Hypotype P34842 F.A. Cudmore Collection. Hypotype P12773, coll. J.F. Bailey.

Type locality. "Lower horizon . . . Spring Creek, south of Geelong", i.e. FL24, cliff section below Bird Rock cap, Bird Rock cliffs, Torquay (Torquay 642518). Jan Juc Formation, Janjukian.

Stratigraphic range. Janjukian, Late Oligocene.

Occurrence. Type locality only.

Material. Type and 14 topotypes.

Comments. As stated by Pritchard (1913: 195) there is a close relationship between this taxon and *A. (W.) tateana* (Johnston) but the latter has bolder costae, a larger and more prominently shouldered body whorl and the spiral sculpture is much finer. *A. (W.) sarissa* (Tate), its successor in younger strata, is more slender, has more prominent spiral sculpture and has axial costae which fade out on the spire whorls as they approach the anterior suture.

Alcithoe (Waihoaia) sarissa (Tate)

Plate 13, figure 5
Plate 14, figures 5, 11
Figure 19

Voluta sarissa Tate, 1889b: 129, pl. 2, figs 1a, b.
Scaphella (Eopsephia) sarissa. – Harris, 1897: 116, pl. 4, figs 16a, b.
Notovoluta sarissa. – Cotton, 1949: pl. 14.

Description. Shell slenderly fusiform, elongate, with prominent acuminate spire. Protoconch coiled with axis of shell, of 1½–2 smooth whorls, initial portion of which frequently exsert. First and second teleoconch whorls flat to gently convex, subsequent whorls more convex but depressed against posterior suture. Axial sculpture of prominent costae of which there are 8–10 on the body whorl; costae on spire extend back from anterior suture to posterior depression and on body whorl are present on posterior third. Fine spiral lirae present over whole spire and posterior half of body whorl. Columella generally with 4 strong plaits of which anterior is weaker and often with weak fifth posterior plait on mature specimens. Canal dorsally reflexed; siphonal notch very broad and shallow; siphonal fasciole a prominent broad low cord.

Dimensions. Lectotype (T578A), L 78, HA37, W22; Hypotype (P38303), L 80, HA40, W21; Hypotype (P38301), L 46, HA20, W12.

Location of types. South Australian Museum: Lectotype T578A, Paralectotypes T578B-G (Muddy Creek). (Tate's figured specimen chosen as lectotype). National Museum of Victoria: Hypotype P38303, F.S. Colliver collection; Hypotype P38301, G.B. Pritchard collection.

Type locality. Lower beds, Muddy Creek, i.e., FL82, Clifton Bank, Muddy Creek, W of Hamilton (Coleraine WD820224). Muddy Creek Formation, Balcombian, Middle Miocene.

Stratigraphic range. Longfordian, Early Miocene Bairnsdalian, Middle Miocene.

Occurrence. FL32, SW end, Jan Juc Beach; FL34, S side, Lake Costin; FL35, SE of Fishers Point; FL38, Curlewis; FL41, Amphitheatre; FL77, Altona Bay Coal Shaft; FL78, Fossil Beach; FL82, Type locality; FL84, Four miles below Morgan; FL87, Lake Bullenmerri; FL98, Native Hut Creek S of Highway, FL100, Murgheboluc 4A; FL102, Warrambine Creek; FL103, Downstream section, Grices Creek; FL104, Manyung Rocks. Gellibrand River horizon not known. South eastern Trunk Sewer between Braeside and Dingley (Fyansford Formation, Balcombian).

Material. Types and numerous topotypes.

Comments. This species is distinguished by its narrow elongate appearance. It is derived from *A. (W.) pueblensis* (Pritchard) from which it differs by being proportionately more elongate with a narrow spire, and by having a prominent siphonal fasciole and slightly coarser spiral lirae. It is placed in *Waihaoia* because of its close affinity to *pueblensis* despite the fact that it has a rather prominent siphonal fasciole, a feature generally weakly developed or absent from species in that subgenus.

Alcithoe (Waihaoia) tateana (Johnston)

Plate 14, figures 4, 6, 7, 12

Voluta tateana Johnston, 1880: 37. – Johnstone, 1888: pl. 30, fig. 3, 3a. – Tate, 1889b: 132, pl. 2, fig. 5. – Pritchard, 1913: 195.

Notovoluta tateana. – Cotton, 1949: pl. 14. – Ludbrook, 1967: 68, pl. 4, figs 1, 2.

Description. Shell fusiform, elongate with high tapering spire and prominently shouldered body whorl. Protoconch of about 2 whorls, somewhat similar to *A. (W.) sarissa*. Spire whorls with bold axial costae on anterior half of whorl and fine close-set spiral threads on posterior half. Body whorl bearing 9–12 costae which extend from shoulder to midline of body whorl and then obsolete. Spiral threads present on shoulder of body whorl. Columella with 4 plaits of which anterior is weaker. Siphonal notch broad; siphonal fasciole poorly developed.

Dimensions. Holotype (Z187), L.75, HA40, W26; Hypotype (T388B), L.70, HA35, W25; Hypotype (P2587), L.59, HA32, W20.

Location of types. Tasmanian Museum: Holotype Z127 R.M. Johnston Collection. South Australian Museum: Hypotype T388B, R. Tate Collection. National Museum of Victoria: Hypotype P2587, E.D. Atkinson Collection.

Type locality. "Table Cape". The preservation of the holotype indicates that it comes from the lower bed, i.e., FL28, lower bed in cliff between Fossil Bluff and 1.5 km towards Table Cape, Wynyard, Tas (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian, Early Miocene.

Occurrence. FL 28, Type locality; FL29, Upper bed, Table Cape.

Material. Types and 20 topotypes.

Comments. Specimens of this species are usually rolled and the delicate spiral sculpture is lost. The tapering spire and massive body whorl distinguish this species from its close relatives *A. (W.) pueblensis* and *A. (W.) sarissa*. The features which distinguish *A. (W.) tateana* from *A. (W.) pueblensis* are discussed in more detail under the description of the latter.

Alcithoe (Alcithoe) H. and A. Adams, 1853

Scaphella (Alcithoe) H. and A. Adams, 1853: 164.

Scapha (Alcithoe). – H. and A. Adams, 1858: 617.

Voluta (Alcithoe). – Crosse, 1871: 293. – Tryon, 1882: 94. – Fischer, 1883: 607.

Fulguraria (Alcithoe). – Cossmann, 1899: 132. – Suter, 1913: 444.

Alcithoe. – Marwick, 1926: 260, 270.

Waihaoia (Palomelon) Finlay, 1926: 432 (Type species (original designation): *Cymbiola lutea* Watson).

Alcithoe (Alcithoe). – Theile, 1929: 348.

Alcithoe (Leporemax) Iredale, 1937: 105 (Type species (original designation): *Voluta fusus* Quoy and Gaimard).

Alcithoe (Carolluta) Iredale, 1937: 105 (Type species (original designation): *Fulguraria hedleyi* Murdoch and Suter).

Gilvostia Iredale, 1937: 105 (Type species (original designation): *Gilvostia ostenfeldi* Iredale.

Alcithoe. – Smith, 1942: 24.

Alcithoe (Alcithoe). – Wenz, 1943: 1342.

Alcithoe (Carolluta). – Wenz, 1943: 1345.

Alcithoe (Gilvostia). – Wenz, 1943: 1345.

Alcithoe (Leporemax). – Wenz, 1943: 1345.

Alcithoe (Alcithoe). – Weaver and du Pont, 1970: 109.

Alcithoe (Leporemax). – Weaver and du Pont, 1970: 113.

Alcithoe. – Dell, 1978: 167–175.

Type species. Subsequent designation (Cossmann, 1899): *Voluta pacifica* Perry, 1810 (= arabica Gmelin, 1791) ICZN Opinion 479, Recent, New Zealand.

Description. Shell medium to large, generally thick, elongate, fusiform, somewhat abruptly contracted anteriorly. Protoconch of 2 to 3 smooth whorls, first slightly irregular and deviated from axis of shell. Spiral sculpture usually absent; axial sculpture usually present in form of costae and often developed into prominent elongate nodules on body whorl, rarely absent. Aperture wide and elongate. Outer lip of aperture thickened and reflexed, often almost winglike posteriorly. Columella bearing 4 strong plaits and often 5 with occasionally the addition of 1 or 2 weaker plaits. Siphonal notch deep; siphonal notch well developed or well marked.

Stratigraphic range. Early Miocene–Recent.

Distribution. Australia, Victoria and South Australia (Late Miocene); Flinders Is. (Pliocene); New Zealand (Early Miocene–Recent). 0–700 m.

Comments. It is not the author's intention to revise the generic status of New Zealand volutes, however, the above synonymy of *Alcithoe* has been compiled since there are representatives of the group in the Australian Tertiary. *Leporemax* Iredale, 1937 was separated from *Alcithoe* on the grounds that it differed in its small size, apertural features, sculpture and plaits. However, Iredale did not state in what manner it differed and other authors, such as Weaver and du Pont (1970), who have accepted *Leporemax* as a subgenus of *Alcithoe*, have cited only its small size and relatively larger, more obtuse protoconch as the features of difference. In the writer's opinion these vary so much within individuals that they are not worthy

of generic significance and as no significant differences can be found between the two taxa *Leporemax* has been relegated to the synonymy of *Alcithoe*.

Carolluta Iredale, 1937 was separated from *Leporemax* on the basis of the type species differing by being of smaller size, narrower and having an elongate spire and narrow aperture. These features are not regarded as being of generic significance.

The type species of *Gilvostia* Iredale, 1937, *G. ostenfeldi* Iredale, is a synonym of *Alcithoe swainsoni* Marwick (Weaver and du Pont, 1970) and accordingly *Gilvostia* has also been placed in the above synonymy. Dell (1978) has discussed the synonymy of *Palomelon* Finlay, 1926 with *Alcithoe*.

At present there are only two species of Australian volute referred by the author to *Alcithoe* s.s., these are *A. macrocephala* Finlay and *A. orphanata* sp. nov. from the Late Miocene and Pliocene respectively. These appear to be isolated immigrants from New Zealand, as there is no close relationship between the two and there are no other species which could link them in a lineage. It seems that the south-eastern Australian area was very much on the fringe of the distribution of *Alcithoe* in the late Tertiary, since the paucity of species present contrasts remarkably with the radiation exhibited by the genus in the New Zealand Tertiary.

A detailed anatomical description of the type species has been given by Ponder (1970).

Alcithoe (Alcithoe) macrocephala (Finlay)

Plate 13, figures 6–8
Figure 18

Voluta capitata Tate, 1889b: 127, pl. 2, figs 3a, b (non Perry, 1811).

Scaphella macrocephala Finlay, 1927: 513.

Description. Shell fusiform with rapidly tapering spire. Protoconch pointed, subconical of 2½–3 smooth rather flattened whorls, coiled with axis of shell and with impressed sutures. First teleoconch whorl with few weak spiral threads, remainder of whorls smooth. Teleoconch whorls markedly depressed at posterior suture and prominently convex at anterior suture. Body whorl tumid, contracted abruptly to siphonal fasciole. Aperture wide, notched posteriorly. Columella with 4 plaits, anterior of which weakest. Siphonal notch broad and deep; siphonal fasciole prominent and bounded posteriorly by a ridge.

Dimensions. Holotype (T389), L62, HA–, W25; Hypotype (SAM P5755), L46, HA27, W18.

Location of types. South Australian Museum: Holotype T389, R. Tate collection; Hypotype P5755, Kimber Collection.

Type locality. "Well sinking, Murray Desert" (Tareena, NSW, fide Tate 1899: 102). Bookpurnong Beds, Cheltenhamian, Late Miocene.

Stratigraphic range. Cheltenhamian, Late Miocene.

Occurrence. Type locality; FL132, Minhamite.

Material. Holotype and hypotype.

Comments. Tate (1889b) compared this species with "*V. pacifica* (= *Alcithoe arabica*) and other members of the section *Alcithoe*; but it has not the outer lip proper to them; from *V. pacifica*, which it resembles most in shape, it differs by its smooth flattish whorls". Cotton (1949) referred this species to *Amoria* but it does not have the regular, conical, multispiral protoconch of that genus. The protoconch is similar to that of *A. swainsoni* figured by Marwick (1926: 261, fig. 1c).

Alcithoe (Alcithoe) orphanata sp. nov.

Plate 13, figures 9–12
Figure 20

Description. Shell fusiform, of moderate size with elongate conical spire. Protoconch of 1½ smooth, somewhat irregularly shaped whorls, first of which is slightly deviated from axis of shell, suture impressed. Spire whorls slightly depressed at suture and slightly convex at anterior suture. Spiral sculpture absent. Axial sculpture of almost obsolete costae present on second and third teleoconch whorl. Body whorl smooth, very slightly concave against posterior suture then regularly convex and tapering anteriorly. Aperture narrow, notched posteriorly. Inner lip thickly callused. Columella with 5 well developed plaits, anterior and posterior of which weaker. Siphonal notch broad and deep; siphonal fasciole prominent.

Dimensions. Holotype (P37635), L105, HA63, W39; Paratype (P37636), L117, HA72, W42.

Location of types. National Museum of Victoria: Holotype P37635, Paratype P37636, coll. T.A. Darragh, D.M. Shanks and H.E. Wilkinson, 10 Feb 1969.

Type locality. Flinders Is., Tas., PL1264, Dam on Block 22 (Lees), Furneaux Estate Sect. A, 11 km ENE of junction of No. 4 and No. 3 Rds (Flinders Is. 987733). Camerot Inlet Formation, Pliocene.

Stratigraphic range. Pliocene.

Occurrence. Type locality; PL1268, North Patriarch Drain, Block 6, 1.1 km E of Link Rd, Memana (Flinders Is., 914741).

Material. Types, 1 topotype and 5 other specimens.

Comments. The overall smoothness of the whorls is the most conspicuous characteristic of this species. In shape it closely resembles the New Zealand Nukumaruan and Castlecliffian species *A. (A.) transformis* Marwick but lacks the tubercles present on the bodywhorl of that species. *A. nukumaruensis* (Marshall and Murdoch) also lacks sculpture but is more elongate and the spire is not conical. The protoconch and apertural features are typical of the *Alcithoe swainsoni* group and it seems probable that *A. orphanata* is derived from a Pliocene member of this group such as *A. irregularis* Marwick as there are no other Australian representatives known.

Ericusa H. and A. Adams, 1858

Zidona (Ericusa) H. and A. Adams, 1858: 619.
Ericusa. – Hedley, 1915: 724.
Alcithoe (Ericusa). – Thiele, 1929: 348.
Mesericusa Iredale, 1929: 181 (Type species (original designation): *M. sowerbyi perspecta* Iredale, 1929).
Ericusa. – Cotton and Godfrey, 1932: 49.
Ericusa (Ericusa). – Wenz, 1943: 1346.
Ericusa (Mesericusa). – Wenz, 1943: 1347.
Ericusa. – Macpherson and Gabriel, 1962: 217.
Ericusa (Ericusa). – Weaver and du Pont, 1970: 50.
Ericusa (Mesericusa). – Weaver and du Pont, 1970: 53.

Type species. Subsequent designation (Cotton and Godfrey, 1932): *Voluta fulgetrum* G.B. Sowerby I, 1825. Recent, Southern Australia.

Description. Shell solid, elongate, fusiform, medium to large size, with elongate spire; whorls rarely with shoulder. Protoconch somewhat globose, medium to large, of 1½–2½ smooth whorls, first deviated at 45° to axis of shell and frequently with initial portion exsert. Spiral sculpture generally weakly developed. Axial sculpture usually absent, but occasionally of large costae or tubercles. Aperture large, lenticular. Outer lip slightly thickened, occasionally produced laterally into winglike expansion.

Columella very arcuate with 3 well developed plaits and often with 1 or more weaker plaits. Siphonal notch very wide; siphonal fasciole absent.

Radula uniserial with tricuspid teeth, the central cusps of which are larger and longer than lateral cusps.

Stratigraphic range. Late Eocene (?)-Recent.

Distribution. Southern Queensland (Moreton Bay) (Recent); New South Wales (Recent); Victoria (Late Eocene (?)–Recent); Northern Tasmania (Early Miocene, Pliocene, Recent); South Australia (Middle Miocene, Pliocene, Recent); Western Australia (South Coast) (Early Pleistocene–Recent). 0–250 m.

Comments. Iredale (1929) erected *Mesericusa* on the basis of the strength and thickness of the plaits of *Ericusa kenyoniana* (Brazier) (= *papillosa* Swainson) compared with *Voluta sowerbyi* Kiener, and on the elongate shape of the latter compared with the former. Weaver and du Pont (1970) maintained *Mesericusa* as a subgenus of *Ericusa* on the basis of the former having a smaller protoconch and a higher spire. However, McPherson and Gabriel (1962) have pointed out that such differences are not of generic significance and synonomised *Mesericusa* with *Ericusa*. The writer fully supports this action and points out that the differences cited are subject to considerable variation from individual to individual within a species.

Though the first named species of *Ericusa* occur in the Late Oligocene of Victoria, there are fragmentary specimens of a species in the Late Eocene Browns Creek Clay, possibly related to *E. atkinsoni* Pritchard. *E. sowerbyi*, represented by the subspecies *pellita*, first appears in the Late Oligocene and ranges through to Recent. The other fossil species, with the exception of *E. atkinsoni*, are closely related to living species. On the basis of anatomy, radula and shell morphology *Ericusa* is most closely related to *Livonia* and some of the early species of that genus such as *L. spenceri* (Pritchard) and *L. stephensi* (Pritchard) are somewhat similar in morphology to *E. atkinsoni*. A common ancestry is therefore suggested.

Of the other genera in the subfamily *Ericusa* has considerable affinity with *Alcithoe* and to a lesser extent with the South American genera *Adelomelon* and *Proscaphella*.

Ericusa sowerbyi pellita (Johnston)

Plate 15, figures 7, 8
Plate 16, figures 4, 5
Plate 17, figures 4, 5
Plate 18, figures 4, 5
Figure 21

Voluta pellita Johnston, 1880: 36.
? Voluta allporti Johnston, 1880: 35.
Voluta pellita. – Johnston, 1888: pl. 30, fig. 2. – Pritchard, 1896: 97.
Voluta halli Pritchard, 1896: 101, pl. 2, figs 1-3.
Voluta pellita. – Pritchard, 1913: 198.
Voluta halli. – Pritchard, 1913: 198.
Ericusa (Mesericusa) pellita. – Ludbrook, 1967: 67, pl. 4, figs 9, 10 (holotype).

Description. Shell narrowly fusiform with regularly convex whorls. Protoconch of 2 smooth whorls

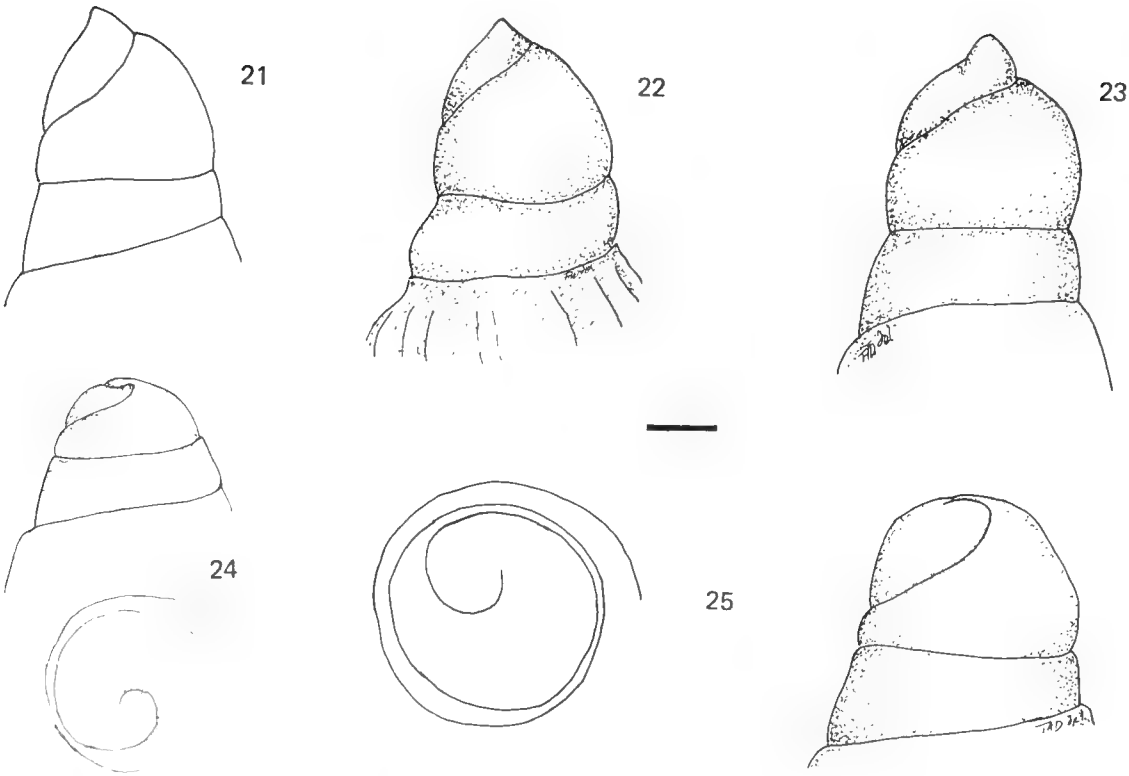

Figure 21. *Ericusa sowerbyi pellita* (Johnston), P41709, hypotype, lower bed, Table Cape, Tas.
Figure 22. *Ericusa atkinsoni* (Pritchard), P41724, hypotype, lower bed, Table Cape, Tas.
Figure 23. *Ericusa macroptera* (McCoy), P61287, hypotype, Bird Rock cliffs, Torquay.
Figure 24. *Ericusa subtilis* (Ludbrook), WAM 69.515, holotype, Hampton Microwave Repeater Tower, WA.
Figure 25. *Ericusa ancilloides* (Tate), P61288, hypotype, Balcombe Bay. (scale = 2 mm)

with initial portion exsert. First and second teleoconch whorls flatly convex and sculptured with numerous close-set spiral threads. Remainder of spire whorls and body whorl gently convex and smooth except for growth striae. Columella with 3 or very rarely 4 plaits.

Dimensions. Holotype (Z156), L116, HA68, W42; hypotype (P41709) (Crushed laterally), L175, HA115, W–; Hypotype (P41710), (FL129), L144, HA73, W47; MUGD 1789 (Crushed laterally), L163, HA85, W–; P41707, L163, HA97, W64; P41708, L120, HA71, W51.

Location of types. Tasmanian Museum: Holotype Z156, R.M. Johnston Collection. Melbourne University Geology Department: Holotype of *Voluta halli* Pritchard, 1896, MUGD 1789, Purchased G.B. Pritchard, 11 Oct 1939. National Museum of Victoria: Hypotype P41709, P41710, F.A. Cudmore Collection.

Type locality. "Table Cape". Preservation of the holotype indicates FL28, lower bed in cliff between Fossil Bluff and 1.5 km NW towards Table Cape, Wynyard, Tas. (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian (Late Oligocene)–? Batesfordian (Middle Miocene).

Occurrence. FL22, Addiscott Beach; FL24, Bird Rock cliffs, FL28, type locality; FL29, upper bed, Table Cape; FL32, Jan Juc Beach; FL34, S of Lake Costin; FL38, Curlewis; FL43, 1.3 km S of Kennedys Creek; FL48, Boornong Road, Cooriemungle.

Material. Holotype and 15 topotypes.

Comments. Johnston (1880) stated that his new species *Voluta allporti* was the largest volute from Table Cape and his description could well apply to *V. pellita*, the next species described on the page. However, the former species has never been figured, no previous authors have used the name and the type specimen is lost, so it seems proper, in terms of Article 24(a) and Recommendation 24A of the Code of Zoological Nomenclature, to continue to use *V. pellita* and place *V. allporti* in the synonomy of this species, though the latter has page priority.

Large specimens from Torquay, the type local-

ity of *V. halli*, are rare and the few that are available show some variation from the type specimen of *V. halli* in that the whorls are inflated as in *V. pellita*. In the upper bed, Table Cape specimens are uniformly slender with flatter whorls than specimens from the bed below. It is felt that this is a phenotypic variation reflecting the differing bottom conditions at the time of deposition, so that *V. pellita* is regarded as having a fair degree of variation in morphology within which fall the Torquay specimens. Until further well preserved material is available from Torquay it seems best to consider *V. halli* as a synonym of *V. pellita*.

The upper limit of the stratigraphic range of the taxon is not known with certainty, since there are a number of broken specimens or juveniles known from higher in the column which may well be this taxon, or perhaps specimens of *Ericusa sowerbyi* s.s.

E. sowerbyi pellita differs from *E. sowerbyi sowerbyi* in having a narrower and more elongate spire and by having stronger spiral threads on the early teleoconch whorls, however, these differences are slight and can only justify subspecific separation.

Cotton (1949) listed the taxon as *Ericusa pellita* and *Mesericusa halli*.

Ericusa sowerbyi sowerbyi (Kiener)

Plate 16, figures 1–3, 7
Plate 17, figure 3
Plate 18, figure 8

Voluta fusiformis Swainson, 1822: 11 (non Brocchi, 1814).

Voluta sowerbyi Kiener, 1839: 47, pl. 50, fig. 2.

Voluta fusiformis. – Swainson and Hanley, 1841: 37. – G.B. Sowerby I, 1845: 208, pl. 54, fig. 100. – Reeve, 1849: pl. 3, fig. 6. – Tryon, 1882: 95, pl. 28, fig. 103.

Mesericusa sowerbyi perspecta Iredale, 1929: 181, pl. 41, fig. 9.

Alcithoe fusiformis. – Smith, 1942: 32, pl. 20, fig. 137

Ericusa sowerbyi porcellana Jackson, 1954: 37.

Mesericusa sowerbyi. McMichael, 1960: 5, fig. 1B (radula).

Mesericusa stokesi Cotton, 1961: (1).

Ericusa (Mesericusa) sowerbyi. – Weaver and du Pont, 1970: 53, pl. 20 E–H.

Ericusa (Mesericusa) stokesi. – Weaver and du Pont, 1970: 54, pl. 20 A–B.

Description. Shell elongate, fusiform with flatly convex whorls. Protoconch of 1½ smooth whorls deviated at about 45° to axis of shell. Spiral and axial sculpture absent. Bodywhorl regularly convex and tapering gradually to anterior, occasionally somewhat depressed at posterior suture. Columella with 3 strong plaits and occasionally with 1 or more secondary plaits. Siphonal notch very wide; siphonal fasciole absent.

Dimensions. Hypotype (P41731), L111, HA65, W46; Hypotype (P41732), L134, HA79, W59; SAM D14625, L135, W58.

Location of types. Syntypes: Not known with certainty (Muséum National d'Histoire Naturelle, Paris, and Muséum d'Histoire Naturelle, Geneva). National Museum of Victoria: Hypotype P41731, coll. P. Roberts Jul 1975; Hypotype P41732, coll. T.A. Darragh, D.M. Shanks and H.E. Wilkinson, 10 Feb 1969. South Australian Museum: Holotype of *Mesericusa stokesi* D14625, presented A.J. Stokes.

Type locality. "les mers de l'Inde". The syntypes were probably collected by one of the French expeditions in Victoria or Tasmania.

Stratigraphic range. Cheltenhamian (Late Miocene)–Recent.

Occurrence. Living. Cape Morton, Queensland–Beachport, South Australia, Northern Tasmania. 40–250 m. Fossil. FL114, bed b. NE side, Bunga Creek; FL115, Lake Bunga tramway crossing; FL119, Ritchies Cutting, Scrivenors Road; FL148, Jemmys Point; FL151, right bank, Meringa Creek; FL156, Glenelg River at Roscoes; FL158, Limestone Creek. Tasmania: Cameron Inlet Formation (Pliocene): PL1258, Dam on lot 47, Memana (Flinders Is. 994657); PL1264 Dam on lot 22, Memana (Flinders Is. 987733); PL1268 North Patriarch drain, block 6, Memana (Flinders Is. 914741).

Comments. *Voluta fusiformis* Swainson, 1822 is preoccupied by Brocchi, 1814 and the next available name for this taxon is *Voluta sowerbyi* Kiener, 1839. The latter is not a replacement name for the former and was described by Kiener without reference to Swainson's name, therefore the types are not those of *Voluta fusiformis* as implied by Weaver and du Pont (1970: 53) but the specimens upon which Kiener based his species.

Of all the Australian species this is perhaps the most featureless and therefore very difficult to characterise. The entry into the stratigraphic record of this taxon is not known with precision owing to the lack of well preserved adult specimens in the Middle Miocene. This taxon is descended from *Ericusa sowerbyi pellita* (Johnston) and further comments are under that taxon.

Cotton (1961) separated *E. stokesi* from *E. sowerbyi* on the basis of it having a bulbous protoconch, a less elongate shell and the fact that it was unicoloured. The size of protoconch and the colour vary from individual to individual and cannot be regarded as of specific value. With regard to shape the holotype and a series of specimens from Port McDonald and Apollo Bay in the col-

lection of F. Rossack have been compared with a series of specimens from southern New South Wales and it is apparent that the holotype of *E. stokesi* is merely a ventricose specimen of *E. sowerbyi* and there is overlap in morphology between the South Australian and New South Wales specimens. Similarly, *E. sowerbyi perspecta* (Iredale) and *E. sowerbyi porcellana* Jackson fall within the range of variation of specimens from South Australia and Bass Strait.

Ericusa macroptera (McCoy)

Plate 15, figures 1, 2
Plate 17, figures 1, 2
Plate 18, figure 3
Figure 23

Voluta macroptera McCoy, 1866: 375.—McCoy, 1874: 29, pl. 7, figs 1–4.—Tate, 1889b: 124.
Pterospira macroptera.—Cotton, 1949, pl. 15.

Description. Shell fusiform with ventricose body whorl and winglike outer lip. Protoconch of about 2 smooth whorls, first of which is larger and has projecting initial portion. Teleoconch whorls depressed posteriorly and convex anteriorly. Spiral sculpture of numerous fine threads on spire whorls but becoming obsolete on penultimate whorl. Axial sculpture of a few weak plicae on first and second teleoconch whorls. Body whorl depressed at posterior suture, ventricose medially and abruptly contracted anteriorly. Outer lip of aperture extended laterally into prominent triangular winglike expansion. Inner lip projecting well beyond outer lip. Columella with 4 plaits. Siphonal notch wide and triangular in shape. Siphonal fasciole absent.

Dimensions. Lectotype (P12379), L125, HA–, W62 (McCoy, 1874, pl. 7, fig. 2); Paralectotype (P12378), L141, HA105, W64 (pl. 7, fig. 1); Paralectotype (P12380), L129, HA78, W55 (pl. 7, fig. 3); Paralectotype (P12381), L41, HA–, W17 (pl. 7, fig. 4); Hypotype (P48588), L134, HA87, W52.

Location of types. National Museum of Victoria: Lectotype P122379, paralectotypes P12378, P12380, P12381, coll. Richard Daintree, G.S.V. Jul and Aug 1861. The best preserved specimen is chosen as lectotype. Hypotype P48588, J. Dennant Collection; Hypotype P61287, F.S. Colliver Collection.

Type locality. Geological Survey of Victoria locality Ad22, Bird Rock Cliffs. This locality is a set of strata from about 5.2 to 11.3 m below the cap of Bird Rock (Torquay 642518). Jan Juc Formation, Janjukian.

Stratigraphic range. Janjukian, Late Oligocene.

Occurrence. Type locality only.

Material. Types and 16 topotypes.

Comments. In overall whorl shape this species resembles *Ericusa fulgetrum* but has a more slender spire and winglike outer lip of the aperture. Pritchard (1913: 199, pl. 20, fig. 6) recorded this species from Table Cape, Tasmania, but the specimen figured is a juvenile of *E. atkinsoni*.

Ericusa atkinsoni (Pritchard)

Plate 19, figures 3, 5
Plate 20, figures 1, 3
Figure 22

Voluta atkinsoni Pritchard, 1896: 100, pl. 3, fig. 1.
Voluta macroptera.—Pritchard, 1913: 199, pl. 20, fig. 6 (non McCoy, 1866).

Description. Shell fusiform with slender rapidly tapering spire of flat to convex whorls and tumid angulate bodywhorl which attenuates abruptly to canal. Protoconch of 2 smooth whorls, somewhat conical in shape with central initial portion projecting posteriorly as in *E. macroptera*. Spire whorls flat to convex and sculptured with low, wide, axial costae and numerous spiral threads. Spiral threads absent from body whorl. Body whorl angulate with well developed shoulder which bears 11–13 prominent oblique tubercles. Columella with 3 strong plaits. Outer lip of aperture slightly reverted laterally and produced posteriorly. Siphonal fasciole not present.

Dimensions. Holotype (P2985), L132, HA85, W66, Hypotype (P41723), L140, HA92, W61.

Location of types. National Museum of Victoria: Holotype P2985, E.D. Atkinson Collection; Hypotype P41723, F.A. Cudmore collection.

Type locality. Table Cape. The preservation of the holotype indicates FL28, lower bed in the cliff between Fossil Bluff and Table Cape, Wynyard, Tas. (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian–Longfordian, Early Miocene

Occurrence. FL28, Type locality; FL32, Jan Juc beach; FL33, Birregurra; FL34, S side of Lake Costin; FL35, SE of Fischers Point; from 19 m in a shaft at Wurdi Boluc, Jan Juc Formation; 73 m, Mundys Well, Canegrass Station, via Kooringa, South Australia.

Material. Holotype and 3 topotypes.

Comments. This species has a similar protoconch to *Ericusa macroptera* and the spire whorls are sculptured in a fashion similar to those specimens of *E. macroptera* which have axial costae and spiral lirae, however, the sculpture is much more strongly developed than in the latter and the aperture also

lacks the well developed winglike extension of *E. macroptera*. Whilst the two are closely related and *E. atkinsoni* succeeds *E. macroptera* it is not clear that the latter is in fact ancestral to the former.

Few fragmentary specimens of a large (170 mm) *Ericusa*, very similar in shape and sculpture to this species have been found in the lower part of the Late Eocene Browns Creek Clay.

Specimens from the Fischers Point area seem to be smaller and have more slender and more elongate spires than topotypes, but there are insufficient well preserved topotypes to determine if there are significant differences between the two populations.

Ericusa ancilloides (Tate)

Plate 15, figures 3–5
Figure 25

Voluta ancilloides Tate, 1889b: 126, pl. 3, fig. 7.
Scaphella ancilloides. – Harris, 1897: 112.
Alcithoe ancilloides. Cossmann, 1899: 133, Fig. 21, pl. 7, fig. 6.
Ericusa ancilloides. Cotton, 1949: pl. 14.
Ericusa (Ericusa) ancilloides. Ludbrook, 1958: 77, pl. 4, fig. 2 (lectotype).

Description. Shell small, fusiform, ventricose with blunt almost conical spire. Protoconch large, of 1½–2 smooth whorls, first of which deviated at slight angle to axis of shell. Teleoconch whorls gently convex, sculptured with growth striae and fine spiral lirae which fade out towards body whorl. Body whorl flattened near margin of aperture, otherwise ventricose at midline and tapering anteriorly. Inner lip extending well beyond outer lip. Columella gently convex and bearing 3 plaits. Siphonal notch wide and deep. Siphonal fasciole absent.

Dimensions. Lectotype (T396D), L76, HA43, W28; Hypotype (P41730), L70, HA44, W29.

Location of types. South Australian Museum: Lectotype T396D, Paralectotypes T396A, C, T393, R. Tate Collection. National Museum of Victoria: Hypotype P41730 coll. David Burn, 12 Jun 1971; Hypotype P61288 coll. F.A. Cudmore. (Tate's figured specimen is chosen as lectotype).

Type locality. "Schnapper Point", i.e., FL78, shore platform at Fossil Beach, 3 km S of Mornington (Western Port 273658). Fyansford Formation Balcombian, Janjukian (Early Miocene)–Bairnsdalian (Middle Miocene).

Occurrence. FL28, lower bed, Table Cape; FL33, Birregurra; FL38, Curlewis; FL43, 1.3 km S of Kennedys Creek; FL48, Boornong Road, Cooriemungle; FL68, SE end of Gibson Beach; FL69, Red Bluff; FL70 Farrells; FL72, Orphanage Hill, Fyansford; FL77, Altona Bay Coal Shaft; FL78, Type locality; FL82, Clifton Bank, FL84, 4 miles below Morgan; FL87, Lake Bullenmerri; FL100, Murgheboluc 4A; FL103, Gunyoung Creek.

Material. Types and 9 topotypes.

Comments. Specimens from Muddy Creek occasionally have rather poorly developed irregular axial costae present on the first and second teleoconch whorls. Comparisons with *Ericua hamiltonensis* (Pritchard) have been made under that species. Of living volutes it most closely resembles *E. sericata* Thornley but is more ventricose in the body whorl and the spire whorls are convex rather than flat as in that species. It may be ancestral to that species.

Ericusa hamiltonensis (Pritchard)

Plate 15, figures 6, 9
Plate 18, figures 2, 7

Voluta hamiltonensis Pritchard, 1898: 107, pl. 8, fig. 5.

Description. Shell fusiform with rather flat spire whorls capped by large, smooth, globose protoconch. Protoconch of 1½–2 whorls, the first of which is deviated 45° to axis of shell. Sutures impressed. Spiral sculpture consisting of 4 or so faint threads confined to first teleoconch whorl. Columella with 3 plaits. Siphonal notch wide and deep; no siphonal fasciole. Colour pattern of thin, widely spaced, zigzag, axial bands.

Dimensions. Holotype (MUGD 1832) L115, HA59, W41; Hypotype (P12566) L101, HA56, W38.

Location of types. Melbourne University Geology Department: Holotype MUGD 1832, purchased G.B. Pritchard, 11 Oct 1939. National Museum of Victoria: Hypotype P12566, purchased R.H. Annear, 23 Jan 1912.

Type locality. "Eocene (i.e. lower) beds, Muddy Creek", i.e. FL82, Clifton Bank, Muddy Creek, 7 km W of Hamilton (Coleraine WD818225). Muddy Creek Formation, Balcombian.

Stratigraphic range. Balcombian, Middle Miocene.

Occurrence. FL71, SW of Glenleigh; FL78, Fossil Beach; FL82, Type locality; Gellibrand River (precise horizon not known).

Material. Holotype and 5 topotypes.

Comments. This taxon differs from *Ericusa ancilloides* (Tate) in having a larger protoconch and hence the spire is not as tapering as in that species, the whorls are flatter and the body whorl is more abruptly contracted anteriorly. Cotton (1949) listed this species under *Cymbiola* but the deviated protoconch, the three plaits, the siphonal notch and absence of fasciole are all typical of *Ericusa*.

Ericusa fulgetroides (Pritchard)

Plate 16, figures 6, 8
Plate 18, figures 1, 6

Voluta fulgetroides Pritchard, 1898: 105, pl. 7, fig. 4.
Ericusa fulgetroides.—Cotton, 1949: 186.

Description. Shell ovately fusiform with somewhat convex whorls and impressed sutures. Protoconch large of 2½ smooth whorls, first of which deviated at 45° to axis of shell. First and second teleoconch whorls gently convex and bearing numerous, close-set, spiral threads which tend to become obsolete towards body whorl. Body whorl smooth except for growth striae, broadly convex and tapering gently to anterior canal. Columella with 3 plaits. Siphonal notch as in *E. sowerbyi*.

Dimensions. Holotype (MUGD1804), L121, HA80, W62; Hypotype (P7843), L118, HA76, W57; P41736, L130, HA60, W82.

Location of types. Melbourne University Geology Department: Holotype MUGD 1804, purchased G.B. Pritchard, 11 Oct 1939. National Museum of Victoria: Hypotype P7843, presented R. Hughan, Dec 1905.

Type locality. "Miocene beds of Muddy Creek, and of Grange Burn, Western Victoria; also from the Miocene deposits of Beaumaris". The preservation of the holotype and the matrix within the shell indicates that it comes from grey silt at base of section at FL137, Forsyths bank, left bank of Grange Burn (Coleraine WD 832237). Grange Burn Formation, Kalimnan.

Stratigraphic range. Kalimnan, Early Pliocene.

Occurrence. FL137, Type locality; FL139, McDonalds Bank.

Material. Holotype and 6 specimens.

Comments. Compared with *Ericusa fulgetrum* (Sowerby) the spire of *E. fulgetroides* is not as high and the whorls are evenly convex; with *E. papillosa* (Swainson) the shell is more ventricose, the whorls evenly not flatly convex and not depressed at the suture. *E. sowerbyi* (Kiener) is the most closely related living species but the spire of *E. fulgetroides* is squatter with fine spiral threads, and the whorls more convex and the sutures somewhat impressed.

A greater series of specimens from Hamilton and also more material of fossil *E. sowerbyi* from Gippsland may show that there is morphological overlap and hence that *E. fulgetroides* is merely a population of the former.

Ericusa subtilis (Ludbrook)

Plate 30, figures 1–4
Figure 24

Notovoluta kreuslerae subtilis Ludbrook, 1978: 166, pl. 19, figs 4, 5.

Description. Shell small, narrowly fusiform with elongate subconical spire. Protoconch of 1½ smooth whorls, first of which slightly deviated from axis of shell. Teleoconch whorls virtually flat and sculptured merely with growth striae. Body whorl tapering gently to anterior. Columella almost straight and bearing 3 or 4 strong plaits. Siphonal notch wide and deep; siphonal fasciole absent.

Dimensions. Holotype (WAM 69.515), L67, HA38, W24; Hypotype (WAM 79.391), L71, HA41, W25.

Location of types. Western Australian Museum: Holotype WAM 69.515, coll. T.A. Darragh, M. Archer and G.W. Kendrick, 5 Mar 1969, Hypotype WAM 79.391, coll. V.A. Ryland, G.W. and W.E. Kenrick, 5–13 Aug 1978.

Type locality. PL3172, Foundation holes for Hampton Microwave Repeater Tower, 53 km E of Madura, Roe Plain, WA (Eucla 365462). Roe Calcarenite.

Stratigraphic range. Roe Calcarenite.

Occurrence. Type locality; Pit 1.5 km N of Hampton Tower, Roe Plain, WA.

Material. Types, 5 topotypes and 6 other specimens.

Comments. As noted under *Notovoluta kreuslerae occulta*, the holotype of *N. kreuslerae subtilis* is an *Ericusa* having the typical deviated protoconch of that genus. This species is the smallest and narrowest of all described species of *Ericusa*. Both *E. ancilloides* and *E. sericata* which bear the closest resemblance to it, are considerably larger and more ventricose and the spire whorls of *E. ancilloides* are convex rather than flat.

Ericusa fulgetrum (G.B. Sowerby I)

Plate 30, figure 7

Voluta fulgetrum G.B. Sowerby I, 1825: 28, pls 4, 5.
Ericusa orca Cotton, 1952: 53, pl. 4, figs 4–6.
Ericusa (Ericusa) fulgetra (sic).—Weaver and du Pont, 1970: 50, pl. 19 A–D, Fig. 9.
Ericusa (Ericusa) orca.—Weaver and du Pont, 1970: 51, pl. 19, E–F, (Holotype).
Ericusa fulgetrum orca.—Lubrook, 1978: 167, pl. 19, figs 2, 3.

Description. Shell large, elongate, ovately fusiform with high almost gradate spire. Protoconch large, papillary, of 2 smooth whorls, first slightly deviated to axis of shell. Teleoconch whorls depressed posteriorly and abruptly contracted anteriorly. Columella with 3 strong plaits. Siphonal notch very broad, siphonal fasciole absent.

Dimensions. Hypotype (WAM 79.410) L124, HA78, W52; Hypotype (WAM 71.337) L102, HA58, W38 (Ludbrook, 1978, pl. 19. figs 2, 3).

Location of types. British Museum (Natural History): Holotype 1837.12.1.37. ex Tankerville collection. South Australian Museum: Holotype of *E. orca* Cotton, 1952, D13816. Western Australian Museum: Hypotype WAM 71.337, coll. A.J. Carlisle, 1968; Hypotype WAM 79.410, coll. V.A. Ryland, G.W. and W.E. Kendrick, 29 Sep 1976.

Type locality. Not stated.

Stratigraphic range. Roe Calcarenite–Recent.

Occurrence. Living: South-east Western Australia to eastern South Australia. Fossil: Roe Plain, WA, Roe Calcarenite: Pit on Eyre Highway, 6.3 km E of Hampton Tower Road; Pit on Eyre Highway near Mundrabilla; Foundation Holes for Hampton Microwave Repeater Tower; Pit 1.5 km N of Hampton Tower.

Material. 4 fossil specimens.

Comments. Weaver and du Pont (1970) have provided good figures and a detailed synonomy of this taxon. *Ericusa orca* is merely an ecomorph from the western end of the range and is synonomised with *E. fulgetrum*.

Ericusa papillosa (Swainson)

Voluta (Scaphella) papillosa Swainson, 1822: 10.
Ericusa (Ericusa) papillosa. – Weaver and du Pont, 1970: 51, pl. 19G I.

Comments. This species has not yet been recorded as a fossil. Weaver and du Pont (1970) have provided good figures, a description and detailed synonomy of this and the following species. The species ranges from Eucla, Western Australia to Central New South Wales and Tasmania.

Ericusa sericata Thornley

Ericusa sericata Thornley, 1951: 53, Fig. 6.
Ericusa (Ericusa) sericata. – Weaver and du Pont, 1970: 52, pl. 20C, D.

Comments. This species has not yet been recorded as a fossil though *E. ancilloides* (Tate) is probably ancestral to it. The species ranges from Central New South Wales to Southern Queensland.

Livonia Gray, 1855

Scapha (Livonia) Gray, 1855a: 8.
Voluta (Mamillana) Crosse, 1871: 308 (Type species (monotypy): *Voluta mammilla* G.B. Sowerby I, 1844).
Voluta (Mamillana). – Tryon, 1882: 101. – Fischer, 1883: 607.
Voluta (Pterospira) Harris, 1897: 100. (Type species (original designation): *Voluta hannafordi* McCoy, 1866)
Voluta (Mamillana). – Tate, 1898: 386, 387.
Mamillana. – Cossmann, 1899: 107.
Pterospira. – Cossmann, 1899: 134.
Voluta (Mamillana). – Dantzenberg, 1901: 10.
Mamillana. – Cossmann, 1901: 253.
Livonia. – Hedley, 1915: 723.
Pterospira. – Cotton and Godfrey, 1932: 48
Cottonia Iredale, 1934: 57 (Type species (original designation): *Scaphella dannevigi* Verco, 1912 = *Voluta nodiplicata* Cox, 1910).
Mamillana. – Smith, 1942: 49.
Pterospira. – Wenz, 1943: 1333.
Cymbium (Mamillana). – Wenz, 1943: 1338.
Alclithoe (Cottonia). – Wenz, 1943: 1344.
Mamillana. – Macpherson and Gabriel, 1962: 218.
Pterospira. – Macpherson and Gabriel, 1962: 220.
Livonia. – Weaver and du Pont, 1970: 47.
Cottonia. – Weaver and du Pont, 1970: 124.

Type species. Subsequent designation by Hedley, 1915: *Voluta mamilla* G.B. Sowerby I, 1844. Recent, south-eastern Australia.

Description. Shell usually large and thick, ovate to ovate fusiform, with prominent shoulder and gradate spire. Protoconch with first whorl large for size of the shell, smooth, globose and deviated at 45°–90° to axis of shell; second whorl usually smaller and merging with teleoconch whorls. Spiral sculpture of threads or lirae usually present on shoulder of spire whorls and obsolete or absent on body whorl. Axial sculpture, if present, of strong ribs, tuberculate at shoulder.

Outer lip of aperture reflected laterally and usually extended laterally and posteriorly into prominent winglike expansion. Inner lip covered with thin glaze. Columella arcuate, usually with 3 strong plaits, though rarely with 2 or 4. Siphonal notch shallow and wide. Siphonal fasciole absent.

Radula uniserial with tricuspid teeth, central cusp larger and longer than lateral cusps.

Stratigraphic range. Late Oligocene–Recent.

Distribution. Southern Australia, New South Wales (Recent); Victoria (Late Oligocene–Recent); Northern Tasmania (Early Miocene, Pliocene, Recent); South Australia (Middle Miocene; Recent); Western Australia (Recent). 20–470 m.

Comments. The species in this genus have the heaviest nodulation of any known volute. Weaver and du Pont (1970) in designating a type species of the genus, have overlooked Hedley's (1915) prior designation. Their copy (Fig. 8a) of Gatlif and Gabriel's (1909) photograph of the radula of *L. mammilla* is incorrect.

Pterospira Harris, 1897, erected on the basis of the winglike outer lip and large globose protoconch, was synonymised with *Mamillana* by Tate (1898)

who pointed out that the latter had a similar protoconch and an incipient winged lip. Hedley (1915) designated *Voluta mammilla* as type species of *Livonia,* a genus which had been overlooked by earlier authors, and therefore *Mamillana* became a junior objective synonym of *Livonia.*

Cottonia was erected by Iredale in 1934 and that author included *Voluta alticostata* Tate and *V. heptagonalis* Tate as possible members of the genus. There was no comparison with other taxa except *Alcithoe.* The protoconch of the type species, illustrated by Wilson and Gillet (1971: 124, Fig. 24) and other features such as the absence of a siphonal fasciole, the presence of three plaits on the columella and the incipient winged lip are all features typical of *Livonia,* hence the writer has synonomised *Cottonia* with that genus. The anatomy of the type species of *Livonia, Pterospira* and *Cottonia* was examined and seems identical in all three.

The earliest known species of *Livonia* makes its appearance in the Late Oligocene of Victoria and there are several species in the Early Miocene of Victoria and Tasmania. Because of the close affinity of these species to Early Miocene species of *Ericusa* a common origin is suggested, and this supposition is born out by a study of the anatomy of species of both genera.

Livonia spenceri (Pritchard)

Plate 23, figure 2
Plate 24, figure 5

Voluta spenceri Pritchard, 1896: 98, pl. 4, figs 1, 2.

Description. Shell broadly fusiform with gradate spire and angular body whorl. Protoconch of 2 whorls, first deviated at about 45° to axis of shell. Spire whorls angulate and bearing close set spiral threads and sharp tubercles on shoulder. Body whorl ventricose, with prominent shoulder, almost keeled and abruptly contracted anteriorly giving quadrate appearance. Shoulder bearing 10 or so prominent blunt tubercles which may extend anteriorly in form of broad low costae. Columella with 3 plaits, outer lip slightly reflected laterally. Fasciole absent.

Dimensions. Holotype (P2990) L97, HA-, W54 (Protoconch and portion of canal missing); Paratype (MUGD 1813) unknown (Curlewis).

Location of types. National Museum of Victoria: Holotype P2990, E.D. Atkinson Collection. Melbourne University Geology Department: Paratype MUGD 1813, Purchased G.B. Pritchard, 11 Oct 1939.

Type locality. "Table Cape". The preservation of the specimen indicates the lower bed, i.e., FL28, lower bed in cliff between Fossil Bluff and Table Cape, N of Wynyard, Tas. (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian (Early Miocene)–? Balcombian (Middle Miocene).

Occurrence. FL28, Type locality; FL32, SW end of Jan Juc Beach; FL38, Curlewis; FL48, Boornong Rd, Cooriemungle; ? FL78, Fossil beach; PL3163, Williams Rd cutting, Cowleys Creek.

Material. Holotype and 1 crushed specimen from FL32.

Comments. The Fossil Beach specimen is narrow, more elongate and has many more tubercles on the shoulder. Because of the rarity of the species it has not been possible to determine whether these differences are significant. The protoconch of this species is somewhat like that of species of *Ericusa* and in this it is similar to *L. stephensi.* The form of the aperture is also like that of *L. stephensi,* however the spire whorls of *L. spenceri* are angulate and bear nodules rather than costae as in the former.

Livonia stephensi (Johnston)

Plate 23, figures 1, 3–6
Plate 30, figures 8, 9
Figure 26

Voluta stephensi Johnston, 1880: 35. – Johnston, 1888: pl. 30, fig. 1. – Tate, 1888: 122. – Pritchard, 1896: 94.
Voluta wynyardensis Pritchard, 1913: 200, pl. 21, figs 1, 2.
Alcithoe (Cottonia) stephensi. – Ludbrook, 1967: 67, pl. 3, figs 3, 4.

Description. Shell fusiform with narrow gradate spire and prominently shouldered body whorl somewhat abruptly contracted to anterior canal. Protoconch moderately large, of 2 smooth whorls, first deviated at about 30° to the axis of spire. First teleoconch whorl convex, remainder of whorls concave posterior to shoulder. Axial sculpture of coarse costae which increase in strength towards aperture but become obsolete on shoulder and nodulate at shoulder. Body whorl with 12–14 short, sinuous tuberculate costae. Spire covered with numerous fine lirae which become obsolete on body whorl. Columella with 3 plaits and rarely fourth feeble plait anterior to others. Outer lip slightly reflected laterally. Siphonal notch wide, siphonal fasciole not present.

Dimensions. Holotype (Z183), L106, HA59, W49; A.L.M. (TM839), Holotype of *Voluta wynyardensis* Pritchard, L78, HA45, W36; Hypotype (P41366), L110, HA65, W52; Hypotype (P41367), L91, HA51, W41.

Location of types. Tasmanian Museum: Holotype Z183, R.M. Johnston Collection. National Museum of Victoria:

Figure 26. *Livonia stephensi* (Johnston), P61290, hypotype, lower bed, Table Cape, Tas.
Figure 27. *Livonia gatliffi* (Pritchard), MUGD 1805, holotype, Clifton Bank, Muddy Creek.
Figure 28. *Livonia mortoni mortoni* (Tate, 1889), P61289, hypotype, lower bed, Table Cape, Tas. (scale = 2 mm).

Hypotypes P41366, P41367, coll. T. A. Darragh, 30 Nov. 1969. Hypotype P61290, E. D. Atkinson Collection, Auckland Institute and Museum, New Zealand. Holotype of *Volutaria wynyardensis* Pritchard, 1913, IM837, H. A. Finlay Collection ex R. N. Atkinson.

Type locality. "Table Cape". The matrix indicates the lower bed, i.e. FL28, lower bed in cliff between Fossil Bluff and Table Cape, 1.5 km NW towards Table Cape, Wynyard, Tasmania (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian (Late Oligocene–Longfordian (Early Miocene).

Occurrence. FL24, Leege Bird Rock cliffs, Type locality.

Material. Holotype, holotype of *L. wynyardensis*, 5 complete and 4 fragmentary topotypes.

Comments. This species lacks the prominently expanded outer lip which is found in most other species of the genus, and the protoconch is more like that found in species of *Ericusa*, however the overall appearance of the shell is more like that of species of *Livonia* and for this reason it is placed in the latter genus.

The type specimen is poorly preserved. One side has been exposed to weathering and the sculpture is almost obliterated, whilst the other side shows signs of the shell having been rolled prior to burial and the fine spiral sculpture is not present. The weathered side was figured by Johnstone and this, coupled with the poor quality of illustration, no doubt led Pritchard (1913) to misidentify the species. He mistook *L. voluminosa* sp. nov. for *L. stephensi* and proceeded to describe as new *Volutaria wynyardensis* which is based on an immature specimen of *L. stephensi* in which the axial costae of the last whorl are not so well developed as is usual in mature specimens.

Livonia mortoni mortoni (Tate)

Plate 22, figures 1–4
Figure 28

Voluta mortoni. Tate, 1889b: 124, pl. 9, fig. 1.
Pterospira mortoni. – Ludbrook, 1967: 67, p. 3, figs 6, 7.

Description. Shell small, delicate, fusiform, generally smooth and with prominently winged aperture. Protoconch of 1½ small, smooth whorls, deviated at about 45° to axis of shell. First teleoconch whorl [illegible], penultimate and body whorls prominently [illegible]. Narrow spiral sculpture. Aperture [illegible]. Columella gently arched with 2 thin well developed plaits and rarely third weaker posterior plait, siphonal notch broad; siphonal fasciole absent.

Dimensions. Lectotype (Z208), L 61, HA –, W 32; Hypotype (P2571), L 73, HA 55, W 36.

Location of types. Tasmanian Museum, Lectotype (herein designated) Z208, R. M. Johnston Collection. National Museum of Victoria, Hypotype P2571, E. D. Atkinson Collection. Hypotype P61289, F. A. Cudmore Collection.

Type locality. "Table Cape". The preservation of the lectotype indicates that it comes from the lower bed, i.e. FL28, lower bed in cliff between Fossil Bluff and Table Cape, N of Wynyard, Tasmania (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. [illegible] Early Miocene.

Occurrence. FL28, Type locality, FL29, upper bed, Table Cape.

Material. Lectotype and 7 topotypes.

Comments. The small size, general smoothness of the shell and the angular whorls distinguish this spe-

cies. The closest relative is *L. mortoni connudata* subsp. nov. whose affinity is discussed under that species. The lectotype has been broken since it was illustrated by Tate (1889b: pl. 9, fig. 1) and portion of the body whorl and columella lost.

Livonia mortoni connudata subsp. nov.

Plate 22, figures 6, 7

Voluta mortoni Tate, 1889b: 124, pl. 9, fig. 2.
Pterospira mortoni.—Cossmann, 1899: 134, pl. 6, fig. 4.—Cotton, 1949: pl. 15.

Description. Shell thin, ovate, of medium size, with regularly convex whorls. Protoconch large, globose, of about 1½ smooth whorls, first deviated at right angles to the axis of shell. Spire whorls convex with traces of incipient spiral threads. Body whorl usually regularly convex, tapering gently to canal and occasionally depressed at posterior suture. No axial sculpture. Columella prominently arched and bearing 3 well developed but thin plaits. Outer lip of aperture everted slightly and expanded posteriorly to form small wing. Siphonal notch shallow and wide; siphonal fasciole absent.

Dimensions. Holotype (P41558), L87, HA62, W43 (Wing broken).

Location of types. National Museum of Victoria: Holotype P41558, G. Sweet Collection. South Australian Museum: Paratype T384, R. Tate Collection (Tate 1889b: pl. 9, fig. 2.)

Type locality. FL82, Clifton Bank, Muddy Creek, 7 km W of Hamilton (Coleraine WD 818225). Muddy Creek Formation, Balcombian.

Stratigraphic range. Balcombian, Middle Miocene.

Occurrence. FL82, Type locality; SE Trunk sewer near Braeside.

Material. Types and 6 specimens.

Comments. This is the Middle Miocene descendant of *L. mortoni mortoni* (Tate) from which it differs in having three well developed plaits, a strongly arched columella, regularly convex rather than shouldered whorls and there is no trace of axial nodules. In overall appearance it resembles in miniature, *L. mammilla*.

Livonia voluminosa sp. nov.

Plate 19, figures 1, 2, 4, 6

Voluta alticostata.—Pritchard, 1896: 103 (non Tate, 1889).
Voluta stephensi.—Pritchard, 1913: 195, pl. 21, figs 3, 4 (non Johnston, 1880).

Description. Shell large, thick, broadly fusiform with gradate spire and ventricose body whorl. Protoconch as in *L. hannafordi*. First teleoconch whorl convex, subsequent whorls angular with prominent flat shoulder. Spiral sculpture of fine lirae on spire whorls, fading out on penultimate and body whorls. Axial sculpture of thick costae present on anterior whorl slope of all teleoconch whorls but first. Body whorl angulate prominently shouldered, abruptly contracted anteriorly and bearing 9-12 prominent short costae tuberculate on shoulder of whorl. Columella with 3 strong plaits. Outer lip of aperture extended posteriorly and laterally into winglike expansion.

Dimensions. Holotype (P41368), L141, HA97, W75 (First whorl of protoconch missing); Paratype (P2986), L184, HA111, W86 (First whorl of protoconch missing); Paratype (MUGD1796), L162, HA90, W81 (First whorl of protoconch missing); P41370, L151, HA-, W75.

Location of types. National Museum of Victoria: Holotype P41368 coll. T.A. Darragh 15 Oct 1971. Paratype P2986, E.D. Atkinson Collection. Melbourne University Geology Department: Paratype MUGD 1796, Purchased G.P. Pritchard.

Type locality. FL28, Lower bed in cliff between Freestone Cove and Table Cape, N of Wynyard, Tas. (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian, Early Miocene.

Occurrence. FL28, Type locality; FL29, Upper bed, Table Cape.

Material. Types and 9 other reasonably complete specimens.

Comments. This species resembles *L. heptagonalis* but has an abruptly contracted body whorl and a greater number of less prominent tubercles on the body whorl. It differs from *L. stephensi* from the same locality, and with which it has been confused, by having a globose protoconch similar to *L. hannafordi*, by having an expanded outer lip, more prominent axial costae, more angulate whorls and generally by its larger shape and crass features. It is probably ancestral to both *L. hannafordi* and *L. heptagonalis*.

Livonia sp. cf. **L. nodiplicata** (Cox)

This record is based on an incomplete external mould (WAM 78.3950) from the Early Miocene Abrakurrie Limestone in Spider Sink (N 41), Madura district, Western Australia (Madura 528087). The specimen is similar in size to the largest specimens of *L. nodiplicata*, but it has a much weaker shoulder which fades out on the penultimate whorl, the shoulder nodules are weaker and fade out on the whorl before the penultimate whorl.

Livonia heptagonalis (Tate)

Plate 21, figures 2, 5
Plate 24, figures 1, 2

Voluta heptagonalis Tate, 1889b: 121, pl. 4, figs 1, 7.
Cottonia heptagonalis. – Cotton, 1949: pl. 14.

Description. Shell solid, large, narrowly fusiform with broad, high, gradate spire and gently tapering body whorl. Protoconch as in *L. hannafordi*. Whorls prominently shouldered and on spire bearing numerous spiral threads which become obsolete on body whorl. Axial costae thick, prominent, extending from shoulder to anterior suture of spire whorls; somewhat tuberculate on shoulder. Costae on last whorl short, much enlarged and produced out and away from aperture; 8–10 costae on body whorl. Columella coated with thick callus and bearing 3 plaits; outer lip slightly everted and flanged posteriorly.

Dimensions. Lectotype (T397A), L 137, HA88, W64 (Tate, 1889: pl. 4 fig. 7), Paralectotype (T397C), L 141, HA , W19, (pl. 4, fig. 1); Hypotype (P13895), L 163, HA99, W78.

Location of types. South Australian Museum: Lectotype T397A, Paralectotype 397C, R Tate Collection. National Museum of Victoria: Hypotype P13895, F.A. Cudmore Collection. The adult specimen figured by Tate is designated lectotype.

Type locality. River Murray cliffs near Morgan, i.e., FL84, left bank of the River Murray at a gully 4.8 km S of Morgan-Cadell Rd, SA (Morgan 790280). Cadell Marl lens, Morgan Limestone, Balcombian.

Stratigraphic range. Balcombian, Middle Miocene.

Occurrence. Type locality only.

Material. Types and 5 topotypes.

Comments. The grotesque tubercles and gentle anterior tapering of the body whorl distinguish this species from *L. hannafordi* and *L. voluminosa* sp. nov.

Livonia hannafordi (McCoy)

Plate 20, figures 5, 6
Plate 21, figures 4, 6
Plate 22, figure 5

Voluta hannafordi McCoy, 1866: 376. – McCoy, 1874: 23, pl. 6, fig. 1. – McCoy, 1876: 25, pl. 36, fig. 1. – Tate, 1889b: 121.
Voluta alticostata Tate, 1889b: 122, pl. 5, fig. 7.
Voluta (Pterospira) hannafordi. Harris, 1897: 100, pl. 4, figs 10a, b.
Pterospira hannafordi. Cossmann, 1899: 134; pl. 6, fig. 6.
Voluta validicostata Dennant and Kitson, 1903: 100, nom. nov. for *V. alticostata* Tate
Pterospira hannafordi. – Cotton, 1949: pl. 14.
Cottonia alticostata. – Cotton, 1949: pl. 14
Pterospira hannafordi. – Wilson and Gillett, 1971: Fig. 25.

Description. Shell broadly fusiform with gradate spire. Protoconch of 2 smooth whorls, first globose and deviated at 45° to axis of shell. Whorls strongly convex, frequently with prominent shoulder particularly on body whorl. Body whorl abruptly contracted to anterior canal. Spiral sculpture confined to posterior half of spire whorls and shoulder area of body whorl and consisting of 6–10 lirae with intercalated fine threads. Axial sculpture variable, occasionally poorly developed or absent but usually present on anterior whorl slope of spire and consisting of broad costae which are nodulate on shoulder. Body whorl usually with 10–12 large tubercles at shoulder. Columella with 3 or occasionally 4 or 5 plaits. Siphonal notch broad; siphonal fasciole poorly developed.

Dimensions. Lectotype (P12155), L150, HA100, W77; T392, L 89, HA58, W50; Hypotype (P12972), L 300, HA180, W140.

Location of types. National Museum of Victoria: Lectotype P12155 (McCoy's figured specimen chosen herein), Paralectotype P6646, presented S. Hannaford, 1 Apr 1857, Hypotype P12972. South Australian Museum: Holotype of *Voluta alticostata* Tate T392 R. Tate Collection.

Type locality. "Clays near the foot of Mount Eliza", i.e. FL103, downstream section at the mouth of Gunyoung Creek, Mount Eliza (Western Port 309712). Fyansford Formation, Bairnsdalian.

Stratigraphic range. Balcombian–Bairnsdalian, Middle Miocene.

Occurrence. FL68, SE end of Gibson Beach; FL69, Red Bluff, Shelford; FL70 Farrells; FL71, SW of Glenleigh; FL72, Orphanage Hill, Fyansford; FL74, SE Trunk Sewer; FL78, Fossil beach; FL81, Overburden, Batesford Quarry; FL82, Clifton Bank, Muddy Creek; FL87, Lake Bullenmerri; FL98, Native Hut Creek, S of highway; FL99, Junction Barwon R. and Native Hut Creek; FL103, Type locality; FL104, Manyung Rocks.

Material. Types, 13 reasonably complete individuals, many fragmentary specimens.

Comments. This is an exceedingly variable species. Specimens from the Fyansford Formation frequently lack any costae or they may be feebly developed, whereas specimens from the Muddy Creek Formation vary, some having no costae or feeble costae, and others have sharp well developed costae. The latter specimens have received the name *Voluta alticostata* Tate, however as there is every

gradation between the two extremes the entire suite of specimens is regarded as a single population.

This species is probably ancestral to *L roadnightae* (McCoy) and possibly also to *L. nodiplicata* (Cox). The largest known specimen of the species (P12972 from Muddy Creek) rivals in size specimens of the latter.

Livonia gatliffi (Pritchard)

Plate 20, figures 2, 4
Plate 21, figures 1, 3
Figure 27

Voluta gatliffi Pritchard, 1898: 108, pl. 8, fig. 6.

Description. Shell small, ovately fusiform with gradate spire. Whorls prominently shouldered and bearing well developed but narrow, sinuous axial costae on anterior whorl slope. Costae somewhat tuberculate on shoulder. Costae number 15–21 on body whorl and extend from shoulder to trace of fasciole. Numerous thin spiral threads present on shoulder of spire whorls which become obsolete and disappear on body whorl. Outer lip slightly everted. Siphonal notch wide; siphonal fasciole present.

Dimensions. Holotype (MUGD 1805), L71, HA37, W31; Hypotype (P41472), L71, HA43, W35 (Protoconch missing).

Location of types. Melbourne University Geology Department: Holotype MUGD 1805 purchased G.B. Pritchard. National Museum of Victoria: Hypotype P41472, J. Dennant Collection.

Type locality. "Eocene beds of Muddy Creek", i.e. FL82, Clifton Bank, Muddy Creek, 7 km W of Hamilton (Coleraine WD818225). Muddy Creek Formation, Balcombian.

Stratigraphic range. Balcombian, Middle Miocene.

Occurrence. Type locality only.

Comments. The sculpture and whorl shape of this species are very similar to those of specimens of *L hannafordi* which were described as *Voluta alticostata*, but the mature shell is considerably smaller and the ribs narrower and more closely spaced. This species and *L. mortoni* are the smallest species in the genus.

Livonia mammilla (G.B. Sowerby I)

Voluta mammilla G.B. Sowerby I, 1844: 149.
Voluta mammilla (sic). – G.B. Sowerby I, 1845: 207, pl. 50, figs 57, 58.
Livonia mammilla. – Weaver and du Pont, 1970: 48, pl. 17 A–C.

Comments. Weaver and du Pont (1970) have provided good figures and descriptions with synonymy of this species. Specimens of this species, or a closely related taxon, occur in the Early Pliocene strata at Jemmys Point, Kalimna and in the Pliocene Cameron Inlet Formation on Flinders Is. The fossils tend to have a more erect spire and better developed shoulders than in living specimens, but there are only three broken specimens available and it is not possible to determine if these differences are of significance.

The species ranges from western Victoria to southern Queensland and Tasmania.

Livonia roadnightae (McCoy)

Voluta roadnightae McCoy, 1881: 88, pl. 7, figs 1, 2.
Livonia roadnightae. – Weaver and du Pont, 1970: 49, pl. 18A–B, Fig. 8b.

Comments. Weaver and du Pont (1970) have provided a synonomy, good figures and a description of this species. It appears to be descended from *L. hannafordi* (McCoy), but there are no known specimens in the fossil record.

The species ranges from southern coast of Western Australia to central new South Wales and northern Tasmania.

Livonia nodiplicata (Cox)

Voluta nodiplicata Cox, 1910: 146, pl. 3.
Scaphella dannevigi Verco, 1912: 225, pl. 13, figs 1, 2.
Cottonia nodiplicata. – Weaver and du Pont, 1970: 124, pl. 54 A–B, Fig. 26. – Wilson and Gillett, 1971: 124, pl. 81, fig. 1, Fig. 24.

Comments. Weaver and du Pont (1970) provided a synonomy, good figures and a description of this species; whereas Wilson and Gillett (1971) illustrated, for the first time, the typical *Livonia* type protoconch, which is usually broken off when specimens are collected. This taxon is most closely related to *L. hannafordi* McCoy. A specimen from the Roe Calcarenite in a pit 1.5 km N of Hampton Tower (WAM 79.402) consisting of the protoconch and half a teleoconch whorl is almost identical to the figure in Wilson and Gillett (1971). Two other specimens from this locality are larger in size and lack the protoconchs. They are similar to living specimens, but the shoulder is not as well developed and the shoulder nodules are not as sharp.

The species ranges from Rottnest Island to Eucla, Western Australia.

Livonia joerinkensi (Poppe)

Cottonia joerinkensi Poppe, 1987: 99, pl. 1, figs 1, 2, 4, 5, 6; pl. 2, figs 7, 8; pl. 3, figs 10, 13.

Comments. This taxon bears a very close resemblence to *Livonia hannafordi*, however, it is more

elongate and lacks the prominent shoulder and wing-like expansion of the outer lip of the latter.

It is recorded from 470 m, 120 km off Mermaid, in the direction of Scott Reef, Western Australia.

Notopeplum Finlay, 1927

Notopeplum Finlay, 1927: 514. – Finlay, 1930: 45. – Cotton and Godfrey, 1932:4. – Wenz, 1943: 1340. – Weaver and du Pont, 1970: 169. – Wilson, 1972: 353.

Type species. Original designation: *Scaphella victoriensis* Cossmann, 1899 = *Voluta polita* Tate, 1887, Miocene, Victoria.

Description. Shell small, thin, ovate-elongate to subfusiform, generally smooth, and covered with brilliant glaze. Adult whorls smooth except for growth striae, juvenile whorls occasionally with axial riblets. Initial portion of protoconch deciduous and sealed off from remainder of protoconch by irregular layer of callus, herein called embryonic scar, which forms blunt tip of spire. Remainder of protoconch not sharply differentiated from spire whorls. Aperture lenticular, about one-half to one-third height of shell. Outer lip of aperture frequently thickened and slightly reflexed dorsally. Inner lip produced anteriorly beyond outer lip. Columella usually with 3 strong plaits and weaker fourth posterior plait, rarely 3 or 5. Anterior plait formed by thickening of anterior portion of columella. Siphonal notch wide and shallow but well defined; siphonal fasciole present but not prominent.

Stratigraphic range. Late Eocene–Recent.

Distribution. Southern Australia. Victoria (Late Eocene–Middle Miocene); South Australia (Late Eocene, Middle Miocene, Recent); Western Australia, south coast (Recent), south-west coast (Recent). 12–200 m.

Comments. The high gloss, smooth shell, nature of protoconch and *Ericusa* like apertural features are the most characteristic features of the genus. Its systematic position has been in doubt ever since the genus was described. Wilson (1972) having described the animal and radula of *N. annulatum* pointed out that the separated salivary glands were similar to the Volutinae and particularly the Scaphellinae however other features were dissimilar. The tricuspid radula resembles that of *Ericusa* as does the external anatomy of the animal, in contra-distinction to that of *Scaphella*. The anterior digestive system has no obvious major distinction from that of *Ericusa,* therefore a place in the Volutidae near *Ericusa* seems reasonable until further information comes to hand. The genus which first makes its appearance in the Late Eocene is endemic to southern Australia and has no obvious ancestry.

Notopeplum protorhysum (Late Eocene), *N. primarugatum* (Early Oligocene) *N. maccoyi maccoyi* (Early Miocene) and *N. maccoyi translucidum* (Early Miocene–Recent) are probably all part of a single evolutionary lineage. The only other described species of the genus are the type species *N. polítum* (Middle Miocene) and *N. annulatum* (Recent).

Notopeplum saginatum Finlay originally included in the genus by Finlay (1930) is not closely related to any of the above species and is better placed in *Notovoluta*.

Notopeplum protorhysum (Tate)

Plate 25, figures 7, 10–11
Figure 31

Voluta protorhysa Tate, 1889b: 126, pl. 2, figs 6a, b.
Notopeplum protorhysum. – Finlay, 1927: 514. – Cotton, 1949: 191, pl. 15. – Ludbrook, 1973: pl. 25, fig. 36.

Description. Shell elongate ovate with somewhat tumid shouldered whorls. Embryonic scar small, flattened, edge ridged and slightly overlapping first teleconch whorl. Spire whorls slightly depressed posteriorly. First teleoconch whorl sculptured with numerous, prominent, thin, transverse ribs strongest on shoulder of second teleoconch whorl and fade out completely at end of third or fourth whorl. Remainder of whorls sculptured merely with growth striae.

Dimensions. Lectotype (T589A), L40, HA20, W14; Hypotype (P31155), L29, HA18, W13 (Blanche Point FL10); Hypotype (P31156), L35, HA–, W– (Blanche Point FL10, distorted); P31157, L24, HA13, W10 (FL11).

Location of types. South Australian Museum: Lectotype T589A, Paralectotypes T589B-D juveniles, R. Tate collection. National Museum of Victoria: Hypotype P31155, coll. T.A. Darragh, Mar 1966. Hypotype P31156, coll. T.A. Darragh, 25 Apr 1969.

Stratigraphic range. Aldingan (Late Eocene).

Occurrence. South Australia, Blanche Point Marl (Aldingan): Type locality; 80 ft, bore 240 (G Heading), Sect. 261, Hd of Yatala, Klemzig; FL10, Lower beds, Blanche Point. Victoria: FL11, BCI, Washout nearest Browns Creek; FL13, BC III, Washout nearest Johanna R.

Material. Types and 10 specimens from Blanche Point, 18 specimens from Browns Creek.

Comments. The shell shape of this species is somewhat variable. The type specimens are rather more elongate than those from Klemzig and Blanche

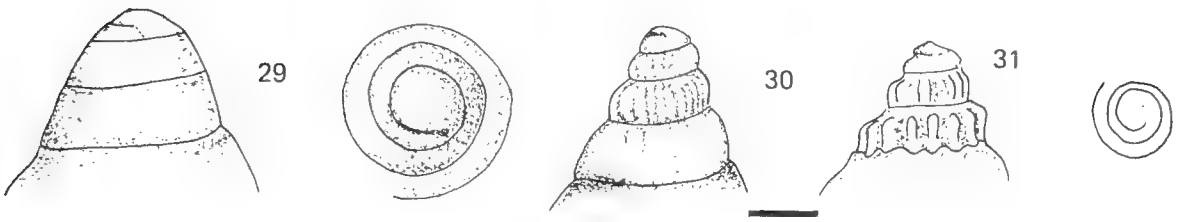

Figure 29. *Notopeplum politum* (Tate), P31164, hypotype, Clifton Bank, Muddy Creek.
Figure 30. *Notopeplum primarugatum* sp. nov., P61291, paratype, Aw 1, Point Flinders.
Figure 31. *Notopeplum protorhysum* (Tate), P31156, hypotype, Blanche Point, SA. (scale = 2 mm)

Point. The Browns Creek specimens have a more prominent shoulder on the early whorls, are less elongate than the types but more elongate than those from Blanche Point. The well developed ribs distinguish this species from others in the genus. A crushed specimen from Browns Creek is 70 mm in length.

Notopeplum primarugatum sp. nov.

Plate 25, figures 1–4, 6
Figure 30

Description. Shell relatively solid, elongately ovate with regularly convex whorls. Embryonic scar small, convex, edge slightly ridged against first teleoconch whorl which is uniformly convex and smooth. Second whorl sculptured with numerous thin, crowded axial riblets which continue onto third whorl where they gradually fade out. Penultimate and final whorls sculptured with growth striae only.

Dimensions. Holotype (P31158), L25, HA13, W9; Paratype (P31159), L26, HA15, W10; Paratype (P33160), L32, HA16, W14.

Location of types. National Museum of Victoria. Holotype P31158, coll. T.A. Darragh, 10 Mar 1977; Paratypes P31159, P31160, P61291, F.A. Cudmore Collection.

Type locality. FL19, Geological Survey locality AW1, W side of Point Flinders near Cape Otway, (Aire 367097). Lower Glen Aire Clay, Upper (?) Aldingan, Early Oligocene.

Stratigraphic range. Upper (?) Aldingan, Early Oligocene.

Occurrence. Type locality only.

Material. Types and 19 topotypes.

Comments. This species is derived from *N. protorhysum* and differs from it in having less prominent but more numerous and closely spaced ribs on the early spire whorls, by not having shouldered whorls and by its more ventricose appearance. The presence of ribs distinguishes it from younger species to which it probably gives rise.

Notopeplum mccoyi mccoyi (Tenison Woods)

Plate 26, figures 1, 6, 11, 12

Voluta m'coyi Tenison Woods, 1877: 95.
Voluta agnewi.—Johnston, 1888: pl. 30, fig. 9 (non Johnston, 1880).
Voluta maccoyii.—Pritchard, 1913: 196 (partim).

Description. Shell elongate ovate with rapidly tapering spire. Whorls gently convex, rarely slightly depressed posteriorly, and sculptured merely with growth striae. Embryonic scar small, irregularly convex, not ridged or overlapping first spire whorl. First teleoconch whorl somewhat tumid and slightly larger than second so that tip of spire has knobbed appearance.

Dimensions. Holotype L30, HA18, W11; Hypotype (P31161), L33, HA18, W13, Hypotype (P31162), L28, HA17, W12.

Location of types. Holotype missing. National Museum of Victoria: Hypotype P31161 Purch. R.N. Atkinson, 8 May 1911. Hypotype P31162 F.A. Cudmore Collection.

Type locality. Table Cape. Herein designated, FL28, lower bed, cliff between Fossil Bluff and Table Cape, N of Wynyard, Tasmania (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian, Early Miocene.

Occurrence. FL28, Type locality; FL29 Upper bed, Table Cape.

Material. 7 topotypes.

Comments. The holotype was not listed by Ludbrook (1967) and enquiry at the Tasmanian Museum has failed to produce the specimen, so it is presumed to be lost. There is no need for a neotype to be selected as Tenison Wood's description and dimensions can only apply to the one taxon. The species name has been applied by both Tate (1889) and Pritchard (1896, 1913) to a closely related taxon, from Victoria, which Finlay subsequently described as *Notopeplum balcombensis* and which the author believes to be synonomous with

N. translucidum, and which also should be regarded merely as a subspecies of *N. mccoyi*.

The specimen figured as *Voluta agnewi* by Johnston (1888) is a typical *N. mccoyi*. Johnston's original description states that *V. agnewi* has 9 or 10 ribs which are raised near the centre into blunt tubercles and, therefore, it cannot be a *Notopeplum*.

Notopeplum mccoyi translucidum (Verco)

Plate 26, figures 2-5, 7-9, 13

Voluta maccoyii. – Tate, 1898b: 126, pl. 2, fig. 2 (non Tenison Woods, 1877).

Voluta translucida Verco, 1896: 217, pl. 6, figs 4, 4 a.

Voluta maccoyi. Pritchard, 1896: 95.

Scaphella maccoyi. – Harris, 1897: 111.

Notopeplum balcombensis. – Finlay, 1930: 46.

Notopeplum translucidum. – Cotton and Godfrey, 1932: 47, pl. 2, fig. 10.

Notopeplum balcombensis. – Cotton, 1949: pl. 15.

Notopeplum translucidum. – Weaver and du Pont, 1970: 170, pl. 73 C, D. Wilson, 1972: 354, pl. 33, figs 5, 6.

Description. Shell elongately ovate, with usually slightly pointed spire and tumid whorls. Embryonic scar small, usually somewhat obliquely flattened so tip of spire may appear pointed. Whorls convex, but generally depressed somewhat at posterior suture, so that whorls are almost shouldered. Colour white with pale chestnut zigzag axial lines.

Dimensions. Holotype (D13614), L40, HA25, W17; Hypotype (D15013), L35, HA21, W16 (W of Eucla); TM1071, L41, HA26, W17 (Holotype of *N. balcombensis* Finlay); Hypotype (P31163), L44, HA26, W18.

Location of types. South Australian Museum: Holotype D13614, Hypotype D15013, Sir Joseph Verco Collection. Hypotype 1382B R. Tate Collection. Auckland Institute and Museum: Holotype of *N. balcombensis* TM 1071, H. Finlay Collection. Museum of Victoria: Hypotype P31163, coll. Sir Robert Blackwood, Jun 1957.

Type locality. Off Newland Head, outside Backstairs Passage, 20 fm, SA.

Stratigraphic range. Longfordian (Early Miocene)–Recent.

Occurrence. Fossil. Slip, edge of Lake Craven, 100 m W of FL36; FL38, Curlewis; FL41, Amphitheatre; FL43, 0.8 miles S of Kennedys Creek; FL46, 0.4 miles S of Kennedys Creek; FL47, Princetown-Simpson Road cutting nearest Melrose Rd; FL48, Boornong Rd cutting; FL60, Lot 393, Tomahawk Creek; FL70, Farrells; FL78, Fossil Beach; FL82, Clifton Bank, Muddy Creek; FL84, 4 miles below Morgan; FL87, NW shore, Lake Bullenmerri; FL100, Murgheboluc 4A; FL103, beds a-f downstream section, Gunyoung Creek; FL104, Manyung Rocks; PL3163, Williams Rd, Cowleys Creek.

Living. Type locality; 6-10 fm, Yatala Shoal, SA; 22 fm, Backstairs Passage, SA; 100 fm, 90 miles W of Eucla, WA.

Material. Holotype and 3 Recent specimens, numerous fossil specimens.

Comments. This is the most common representative of the genus and has the longest stratigraphic range and the widest geographic distribution. It differs from *N. mccoyi* s.s. by its more ventricose whorls and by the presence of a depression close to the posterior suture. These differences are slight but appear to be consistent within the material available so that subspecific separation from *mccoyi* seems justifiable. Shell shape is somewhat variable though, ranging from the relatively squat specimens of Fossil Beach (*N. balcombensis* Finlay) to the relatively elongate specimens of Clifton bank. Living specimens are intermediate between these two, but there is overlap between populations from all localities. The shoulder though usually present, varies in degree of development from complete absence to prominent within the one population. Fossil specimens frequently attain a length of 50 mm or more.

Notopeplum politum (Tate)

Plate 25, figures 8, 9, 12
Figure 29

Voluta polita Tate, 1889b: 127, pl. 2, fig. 7.

Scaphella polita. – Harris, 1897: 112, pl. 4, figs 15a, b (protoconch).

Scaphella polita. – Harris, 1897: 112, pl. 4, figs 15a, b (protoconch).

Scaphella victoriensis Cossmann, 1899: 127, nom. nov. for *Voluta polita* Tate non Conrad (invalid name change).

Notopeplum victoriensis. – Finlay, 1927: 513.

Notopeplum politum. – Wilson, 1972: 357, fig. C (protoconch of holotype).

Description. Shell ovate with tumid whorls and blunt spire. Suture somewhat impressed. Whorls regularly convex sculptured merely with growth striae. Embryonic scar large and convex forming low dome on point of spire.

Dimensions. Lectotype (T602A), L28, HA18, W13; Hypotype (P31164), L30, HA20, W14; P31165, L30, HA19, W14.

Location of types. South Australian Museum: Lectotype 1602A, Paralectotypes 1602B-F, R. Tate Collection. National Museum of Victoria: Hypotype P31164, J. Jutson Collection.

Type locality. Lower beds at Muddy Creek, i.e., FL82, Clifton Bank, Muddy Creek, Hamilton (Coleraine 820224). Muddy Creek Formation, Balcombian, Middle Miocene.

Stratigraphic range. Balcombian (Middle Miocene).

Occurrence. Type locality only.

Material. Types and 17 topotypes.

Comments. The specimes is not common but is distinguished from other species in the genus by its ventricose whorls, impressed sutures and blunt spire. Cossmann's name change is invalid as the supposed senior homonym is *Caricella polita* Conrad, 1854, originally described as a *Caricella* and still placed in that genus.

Notopeplum annulatum Wilson

Plate 25, figure 5
Plate 26, figure 10

Notopeplum annulatum Wilson, 1972: 354, pl. 33, figs 1–4; Figs A, B, D, F–H.

Description. Shell elongate with high spire and slightly convex, almost flat whorls. Colour cream to apricot with poorly developed pale spiral bands with orange blotches.

Dimensions. Holotype (WAM 132-64), L54, HA29, W19.

Location of types. Western Australian Museum: Holotype WAM 132-64, Paratype WAM 134-64 coll. HMAS "Diamentina", 12 Oct 1963; Paratype WAM 472-71 coll. HMAS "Diamentina", 28 Aug 1963.

Type locality. CSIRO Station 225 (32°00'S, 115°, 16'E), W of Rottnest Is., Western Australia, 141–146m.

Occurrence. Type locality; CSIRO Station 144 (32°00'S, 115°08'E), W of Rottnest Is, 141 m; NW of Rottnest Is, 156 m, Western Australia.

Material. Holotype.

Comments. Wilson (1972) has described this species in great detail. It differs from all others in the genus by its elongate appearance and almost flat whorls.

Cymbiola Swainson, 1831

Cymbiola Swainson, 1831: 83.
Aulica Gray, 1847: 141 (Type species (original designation): *Voluta aulica* G.B. Sowerby I.)
Scapha Gray, 1847: 141 (Type species (original designation): *Voluta vespertilio* Linneus) (non Molchulsky, 1845, Coleoptera).
Vespertilio Morch, 1852: 123 (Type species (original designation) *Voluta vespertilio* Linneus) (non Linneus 1758, Mammalia).
Melo (Ausoba) H. and A. Adams, 1853: 160 (Type species: (monotypy) *Voluta cymbiola* Gmelin).
Aulica.—H. and A. adams, 1853: 160.
Voluta (Vespertilio).—Tryon 1882: 86.
Voluta (Aulica).—Tryon, 1882: 87.
Voluta (Vespertilio).—Fischer, 1883: 607.
Voluta (Aulica).—Fischer, 1883: 607.
Voluta (Cymbiola).—Fischer, 1883: 607.
Voluta (Aulica).— Harris, 1897: 101.
Vespertilio.—Cossmann, 1899: 117.
Vespertilio (Aulica).—Cossmann, 1899: 106.
Voluta (Aulicina) Roverato, 1899: 103, nom. nov. pro *Vespertilio*.
Voluta (Eteroaulica) Roverato, 1899: 103, footnote, nom. nov. pro *Aulica* Gray, Invalid replacement.
Cymbiola.—Hedley, 1915: 723.
Aulica (Aulica).—Thiele, 1929: 348.
Aulica (Ausoba).—Thiele, 1929: 348.
Aulica (Aulicina).—Thiele, 1929: 349.
Cymbiolena Iredale, 1929: 181 (Type species (original designation): *Voluta magnifica* Gebauer).
Cymbiola (Cymbiolacca) Iredale, 1929: 181 (Type species (original designation): *Cymbiola complexa* Iredale).
Aulica.—Smith, 1942: 34.
Cymbiola (Cymbiola).—Wenz, 1943: 1335.
Cymbiola (Aulicina).—Wenz, 1943: 1335.
Cymbiola (Aulica).—Wenz, 1943: 1335.
Adelomelon (Cymbiolena).—Wenz, 1943: 1349.
Volutocorona Pilsbry and Olsson, 1954: 25 (Type species (original designation): *Voluta imperialis* Lamarck).
Cymbiola.—McMichael, 1959a: 375.
Aulica (Aulica).—McMichael, 1959a: 375.
Aulica (Aulicina).—McMichael, 1959a: 375.
Pseudocymbiola McMichael, 1961: 54 (Type species (original designation): *P. provocationis* McMichael).
Cymbiola (Cymbiola).—Weaver and du Pont, 1970: 76.
Cymbiola (Aulica).—Weaver and du Pont, 1970: 76.
Cymbiola (Aulicina).—Weaver and du Pont, 1970: 84.
Cymbiola (Cymbiolena).—Weaver and du Pont, 1970: 90.
Cymbiolacca.—Weaver and du Pont, 1970: 92.

Type species. (Tautonomy): *Voluta cymbiola* Gmelin, 1791. Recent, Moluccas.

Description. Shell small to large, solid, squat to ovate with gradate to subconical spire. Protoconch multispiral of 3 to 4 whorls, coiled with axis of shell. Protoconch whorls either smooth, or with weak to strong axial costae, frequently shouldered. Spiral sculpture absent. Axial sculpture generally developed, but occasionally reduced or absent; usually in form of spinose or blunt nodules on shoulder of whorls, sometimes in the form of thin axial costae developed over whole whorl, costae terminating posteriorly in spines on shoulder of whorl. Columella with 4 to 5 strong plaits, occasionally with 1 or more weaker posterior plaits, or with secondary plaits inserted between others. Siphonal notch narrow and deep. Siphonal fasciole prominent, usually bounded posteriorly by thin low ridge.

Radula uniserial with tricuspid teeth, central cusp longest.

Stratigraphic range. Late Oligocene–Recent.

Distribution. South China Sea–Philippines (Recent); Indonesia (Late Miocene–Recent); New Guinea–Solomon Is., Northern Australia (Recent); Southern Australia; Victoria (Late Oligocene–Early Pliocene), Flinders Is., (Pliocene); South Australia (Middle Miocene, Pliocene), Western Australia (Middle Miocene, Early Pleistocene–Recent).

Comments. Of the names in the above synonomy *Scapha* and *Vespertilio* are secondary homonyms as indicated, *Ausoba* is a junior objective synonym of *Cymbiola* and *Eteroaulica* is an invalid replacement name for *Aulica*. The other taxa are synonomised as the writer considers the grounds of separation from *Cymbiola*, cited by the various authors, are not of sufficient worth to warrant separation either at the generic or subgeneric level.

Cymbiola and *Aulica* were distinguished by McMichael (1959a) on the basis of the former having a low spire, and the position of the spines which are high up on the whorls of the former; and by Weaver and du Pont (1970) on the basis of the small low protoconch, low spire and presence of six columella plaits in *Cymbiola*. All these features may vary even from individual to individual, for example, in *C. aulica* (G.B. Sowerby I) and *C. flavicans* (Gmelin), and are certainly gradational between species. Compare for example the gradation in the series *C. cymbiola* (Gmelin), C. flavicans, C. aulica, C. chrysostoma (Swainson) and *C. imperialis* (Lightfoot) as illustrated in Weaver and du Pont (1970).

Aulicina has been distinguished from *Cymbiola* on the basis of its ribbed or nodulose protoconch however, whilst some species are strongly ribbed, others have large to small tubercles and there are others, such as *C. deshayesi* (Reeve) and *C. norrisii* (Gray), in which the ribs or tubercles are considerably reduced or even absent. *Cymbiola rossiniana* (Bernardi), previously placed in *Aulica*, does in fact show obsolete ribs on some specimens. The Pliocene *C.* cf. *rossiniana* also has obsolete ribs and specimens of *C.* cf. *irvinae* from the Roe Calcarenite of Western Australia show obsolete to weak ribs or tubercles. Specimens of *C. complexa* (Iredale) from the Cape Morton area either have strong ribs on the protoconch or the protoconch is completely smooth. Therefore, the presence or absence of ribs or tubercles on the protoconch does not seem to be a consistant feature and therefore *Aulicina* is regarded as a synonym of *Cymbiola*.

Cymbiolacca was erected as a subgenus of *Cymbiola* on the grounds that it differed from the latter in not having the planate protoconch of *Cymbiola*. McMichael (1959a) raised the taxon to genus on the grounds that the protoconch was conical and ribbed, rather than planate and smooth as in *Aulica*, and that the shells were small and light with small knobs and spines. Weaver and du Pont (1970) stated that *Cymbiolacca* was close to *Aulicina* but had a smaller conical protoconch and often more numerous plaits. The species placed in *Cymbiolacca* are merely smaller versions of such species as *C. vespertilio* (Linnaeus), *C. deshayesi* and *C. aulica*. The size of protoconch is not considered to be of generic significance and is comparable to that of *C. flavicans*. The presence and absence of protoconch ribs on specimens of *C. complexa* has been noted above. The number of plaits present is usually four, though *C. perplicata* (Hedley) and *C. thatcheri* (McCoy) have additional smaller posterior plaits. *Cymbiolena* was erected on the basis of its large size, delicate plaits and regularly wound, small protoconch. Weaver and du Pont (1970) accepted the taxon as a subgenus of *Cymbiola*, the only obvious difference between the type species and species of *Cymbiola*, apart from that of size, appears to be the absence of spines on the shoulder of the former, and as this feature is variable within other species of the group, such as *C. nivosa* (Lamarck), *Cymbiolena* has been synonomised with *Cymbiola*.

Weaver and du Pont (1970) have already placed *Pseudocymbiola provacationis* McMichael in synonomy with *C. complexa* and the writer supports this action. These authors also have synonomised *Volutocorona* on the grounds that the cited criteria for separation are of little importance for generic and subgeneric separation. The writer also agrees with this action.

The anatomy of many of the species allocated to the above taxa (see Appendix 2) has been examined and seems identical, providing no evidence to support the separation of any of the taxa.

Wenz (1943) listed the stratigraphic range and distribution of *Cymbiola (Aulicina)* as Late Cretaceous to Recent, Europe, North Africa, West Africa, India, Sunda Is. and Australia. These records are based, in part, on the occurrence of species of Vasidae, such as *Eovasum frequens* (Meyer-Eymer) and *E. haimei* (d'Archaic), which have a superficial resemblance to Volutidae and, in particular, to species of *Cymbiola*. These vasids are common in the Late Cretaceous and Early Tertiary of Africa and India. The writer is not aware of any undoubted records of the genus beyond that cited above under stratigraphic range and distribution.

In the Tertiary of south-eastern Australia *Cymbiola* appeared first in the Late Oligocene along with a number of Indo-Pacific (Tethyan) immigrants during the mid-Tertiary rise in sea tem-

perature, and became extinct in the late Pliocene as the seas cooled. It appears that even in the Tertiary south-eastern Australia was a marginal area in the distribution of *Cymbiola* as specimens are not common.

Cymbiola uncifera (Tate)

Plate 24, figures 4, 7

Voluta uncifera Tate, 1888: 176, pl. 12, fig. 10 (figure only).
Voluta uncifera.—Tate, 1889b: 124 (description).

Dimensions. Lectotype (T394B), L37, HA–, W22; Paralectotype (T394A), L33, HA22, W20.

Location of types. South Australian Museum: Lectotype T394B, Parlectotype T394A, R. Tate collection. Tate's figured specimen is selected as lectotype.

Type locality. River Murray Cliffs near Morgan, i.e., FL84, left bank of River Murray at gully 4.8 km S of Morgan-Cadell Rd SA (Morgan 790280). Cadell Marl lens, Morgan Limestone, Balcombian, Middle Miocene.

Stratigraphic range. Balcombian, Middle Miocene.

Occurrence. Type locality only.

Material. Types and 2 topotypes, all juveniles.

Comments. This species was based on two juvenile specimens and another two juveniles are present in the Cudmore Collection, National Museum of Victoria. The obvious point of difference between these and specimens of *C. macdonaldi* (Tate) is the presence of a single costa in the former rather than paired costae which appear to be characteristic of the latter. The points of difference mentioned by Tate, viz. a more convex and feebly ridged protoconch, a more attenuated body whorl and the presence of nine spines on the shoulder in *C. uncifera*, are subject to such variation in *C. macdonaldi* that they have little value in specific differentiation of juvenile shells. Until more material is available a valid comparison between the two cannot be made.

Cymbiola macdonaldi (Tate)

Plate 24, figures 3, 6

Voluta macdonaldi Tate, 1888: 176, pl. 12, fig. 11 (figure only).—Tate, 1889b: 123, pl. 3, fig. 5.
Voluta (Aulica) macdonaldi.—Harris, 1897: 106.
Cymbiola macdonaldi.—Cotton, 1949: pl. 14.

Description. Shell oblong-ovate with gradate spire. Protoconch of 3 to 4 whorls which are shouldered, spirally lirate, prominantly axially costate and merge with teleoconch whorls. First and second teleoconch whorls bearing from 12 to 20 sinuous costae which become less prominent and finally absent on third teleoconch whorl. Costae paired and each pair merge at shoulder and capped by prominent spinose scale. Body whorl ventricose without costae and having prominent shoulder bearing about 16 large spinose nodules. Columella with 4 strong plaits. Siphonal notch deep; siphonal fasciole prominent and bounded posteriorly by sharp ridge. Colour pattern of numerous triangular patches similar to those present in *Cymbiola rossiniana*.

Dimensions. Holotype (T381D), L30, HA20, W20; Hypotype (T381A), L119, HA76, W66.

Location of types. South Australian Museum: Holotype T381D. Hypotype T381A, R. Tate collection.

Type locality. "Schnapper Point", i.e., FL78, shore platform at Fossil Beach, 3 km S of Mornington (Western Port 273658). Fyansford Formation, Balcombian.

Stratigraphic range. Batesfordian (?) (Early Miocene)-Balcombian (Middle Miocene).

Occurrence. ?FL50, Top of Fischers Point; FL71, SW of Glenleigh; FL78, Type locality; FL82, Clifton Bank; Gellibrand River, horizon not known.

Material. Types and 5 topotypes.

Comments. The paired costae terminating in the shoulder spines are the most characteristic features of this species. The single juvenile specimen from Fischers Point has this feature and hence is tentatively included in the species. This is not a common species and adult specimens are rare. Its relationship with younger species is not clear though it may well give rise to *Cymbiola* cf. *rossiniana*. There are juvenile specimens and one mature (?) specimen of a species of *Cymbiola* in the Jan Juc Formation which may be ancestral to *C. macdonaldi*, however the material is not sufficient for formal description. As far as the writer is aware this constitutes the oldest undoubted record of the genus.

Cymbiola sp. cf. **C. rossiniana** Bernardi

Cymbiola (Aulicina) irvinae.—Ludbrook, 1973: pl. 28, fig. 107.

Comments. There are fragmentary specimens of a species from the Grange Burn Formation (Kalimnan, Early Pliocene) which compare closely with specimens of the living species *Cymbiola rossiniana* Bernardi, 1859 from New Caledonia. A juvenile specimen from the Cameron Inlet (Pliocene) of Flinders Is. may also be the same species and represents the youngest record of the genus in the stratigraphic column of south-eastern Australia. Similar specimens occur in the Late Pliocene Dry

Creek Sands of South Australia, recorded by Ludbrook (1973) as *C. irvinae* (E.A. Smith), a closely related living species from Western Australia. Ludbrook (1973, 1978) recorded *C. irvinae* from the Roe Calcarenite of Western Australia. Specimens from this locality are larger than typical *irvinae* from Rottnest Is. and are somewhat intermediate in morphology between the latter and the specimens from the Grange Burn Formation. The available material from the Pliocene is poor, but suggests that the Pliocene taxon is ancestral both to *C. rosmaniana*, now confined to New Caledonia on the east of the Australian continent and also, in view of the Roe Calcarenite material, to *C. irvinae* now confined to the west coast of Australia. Cooling of temperatures toward the end of the Tertiary may have lead to extinction of *Cymbiola* on the south coast of Australia and the contraction of the ranges of species.

Cymbiola irvinae (Smith)

Voluta irvinae Smith, 1884: 97, pl. 5/8 (Rottnest I., W.A.)
Cymbiola (Aulacina) irvinae — Weaver and St. Peter, 1970: 45, pl. 35 A-C. — Ludbrook, 1973: 164, pl. 1a–c, 2a–c, 3.

Comments. The above authors provide good descriptions and figures of this species. This species occurs in the Early Pleistocene Roe Calcarenite of the Roe Plain, Western Australia; however, as noted above, specimens from there are larger than topotypes of the species and have higher, more gradate spires. In some specimens, the shoulder is not angular, but rounded and lacks any spinose sculpture. Such variation is also seen in the living populations of the species. Wilson (1971) pointed out that there is some degree of overlap in morphology between *C. irvinae* and *C. nivosa* (Lamarck).

Cymbiola sp. cf. **C. nivosa** (Lamarck)

Comments. This record is based on a poorly preserved fragmentary specimen from the Middle Miocene Trealla Limestone on the E flank of Cape Range at Geological Survey of Western Australia locality 30055. It is a small *Cymbiola* akin to *C. nivosa* Lamarck, 1804 but the preservation prevents detailed comparison. It is mentioned here as the specimen is the earliest record for the north and western half of the continent.

Melo Broderip in Sowerby, 1826

(= *Melocorona* Pilsbry and Olsson, 1954)

?Melo sp.

Comments. Three fragmentary juvenile specimens from the Middle Miocene Trealla Limestone at Geological Survey of Western Australia locality 30055, E flank of Cape Range are available. They seem to belong to a species of *Melo* in which case they constitute the only Australian fossil record, but until more mature specimens are available the record should be treated as doubtful as there is a slight possibility that they are juvenile specimens of an undescribed *Cymbiola*.

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Appendix 1. Collecting localities

The localities FL1 etc used throughout this paper are equivalent to PL3001 etc in the Museum of Victoria, Department of Invertebrate Palaeontology, locality data file.

For each locality listed here, exact locality, grid reference, formation, epoch and local stage are given. Yard grid references are given in brackets.

PL 3001, SE side of Dilwyn Cove, N side of Bell Point, 6 km SE of Princetown, from boulders on beach derived from 0.5 m grey (weathered) sandstone about 15 m above beach, Victoria, Princetown 903097, Pebble Point Formation, Middle Paleocene, Wangerripian (Yard grid ref. Princetown 083222).

PL 3002, N side of Dilwyn Cove, S side of Pebble Point, G.S.V. loc. Aw6, 5 km SE of Princetown, Victoria, Princetown 900103, Pebble Point Formation, Middle Paleocene, Wangerripian (Yard grid ref. Princetown 081229).

PL 3003, Cove between Buckley Point and Point Pember, 4.5 km SE of Princetown, Victoria, Princetown 894109, Pebble Point Formation, Middle Paleocene, Wangerripian (Yard grid ref. Princetown 076234).

PL 3004, Shelly band about 10 m above beach, NW side of Buckley Point, 4 km SE of Princetown, Victoria, Princetown 891113, Pebble Point Formation, Middle Paleocene, Wangerripian (Yard grid ref. Princetown 074235).

PL 3005, W end of large slip at Killara Bluff at top section, allot. 4, sect. A, Parish of Killara, Victoria, Dartmoor WD313291, Bahgallah Formation, Middle Paleocene, Wangerripian.

PL 3006, Ironstone about 100 m above river, right bank of Glenelg River on Hazell Bank, Bahgallah, Victoria, Dartmoor WD324296, Bahgallah Formation, Middle Paleocene, Wangerripian.

PL 3007, Middle of Rivernook Beach, SE side of where track comes down, 0.4 km SW of Rivernook, Victoria, Princetown 888119, Dilwyn Formation, Rivernook Member, Late Paleocene, Wangerripian (Yard grid ref. Princetown 066247).

PL 3008, Rivernook Beach, half-way between PL 3009 and Rivernook bed, Victoria, Princetown 887120, Dilwyn Formation, Late Paleocene, Wangerripian (Yard grid ref. 0652548. Younger than Rivernook Member).

PL 3009, G.S.V. loc. Aw7, Rivernook Beach, black silt beneath outcrop of indurated siltstone, 1.5 km SE of Point Ronald, 0.4 km due W of Rivernook, Victoria, Princetown 885123, Dilwyn Formation, *Trochocyathus* band, Late Paleocene, Wangerripian (Yard grid ref. Princetown 063250).

PL 3010, Lower 6.5 m of cliff on S side of Blanche Point, Port Willunga, South Australia, Noarlunga 689963, Blanche Point Marl, Late Eocene, Aldingan (Yard grid ref. Echunga 475452).

PL 3011, BC1, 9.6 m dark clay with *Turritella* below green sand in Washout 1 nearest mouth of Browns Creek, Johanna, Victoria, Princetown 080057, Browns Creek Clay, Late Eocene, Aldingan (Yard grid ref. Aire 277177).

PL 3012, BCII, greensand in washout 1 nearest mouth of Browns Creek, Johanna, Victoria, Princetown 080057, Browns Creek Clay, Late Eocene, Aldingan (Yard grid ref. Aire 277177).

PL 3013, BC III, dark gritty clay 16 m above greensand in Washout 1 nearest mouth of Browns Creek, Johanna, Victoria, Princetown 080057, Browns Creek Clay, Late Eocene, Aldingan (Yard grid ref. Aire 277177).

PL 3014, BCIII, dark gritty clay, in washout 2, forked gully nearest mouth of Johanna River, Johanna, Victoria, Princetown 079059, Browns Creek Clay, Late Eocene, Aldingan (Yard grid ref. Aire 276179).

PL 3015, Marl with bivales, above dark gritty clay in W (right) fork of washout 2, forked gully nearest mouth of Johanna River, Johanna, Victoria, Princetown 079059, Browns Creek Clay, Late Eocene, Aldingan (Yard grid ref. Aire 276179).

PL 3016, G.S.V. loc. Aw5, 220 mm bed with smooth pectinids, lowest fossiliferous outcrop at W end of Castle Cove, Glenaire, Victoria, Princetown 105044, Browns Creek Clay, Late Eocene, Aldingan (Yard grid ref. Aire 306163).

PL 3017, Cutting on Great Ocean Road about 0.4 km NW of Hamilton Creek bridge, Hordern Vale, Victoria, Princetown 168065, Browns Creek Clay, Late Eocene, Aldingan (Yard grid ref. Aire 372187).

PL 3018, Bed of Hamilton Creek, about 0.6 km upstream from the Great Ocean Road, Hordern Vale, Victoria, Otway 172069, Browns Creek Clay, Late Eocene, Aldingan (Yard grid ref. Otway 626192).

PL 3019, G.S.V. loc. Aw1, slips immediately N of Point Flinders, near Cape Otway, Victoria, Princetown 162983, Glenaire Clay, Early Oligocene (Yard grid ref. Aire 367097).

PL 3020, G.S.V. loc. Aw4, Middle Beach, Aire Coast, clays beneath limestone, Victoria, Princetown 121030, Glenaire Clay, Early Oligocene (Yard grid ref. Aire 323147).

PL 3021, Left bank Duck Creek opposite junction with Deep Creek, clay beneath limestone, Hordern Vale, Victoria, Princetown 168034, Glenaire Clay, Late Eocene (Yard grid ref. Aire 374152).

PL 3022, Cliff section Addiscot Beach, beds Bl09–107, SW of small gully, clay overlying Demons Bluff Formation, Victoria, Torquay BT619490, Jan Juc Formation, Late Oligocene, Janjukian (Yard grid ref. Anglesea 354675. Lower Jan Juc Formation).

PL 3023, Addiscot Beach, Bed Bl00, clay immediately beneath the Point Addis Limestone, SW side of Bell Headland, Victoria, Torquay BT620491, Jan Juc Formation, Late Oligocene, Janjukian (Yard grid ref. Anglesea 356676).

PL 3024, Cliff section opposite Bird Rock, below Bird Rock cap, Torquay, Victoria, Torquay 642518, Jan Juc Formation, Late Oligocene, Janjukian (Yard grid ref. Anglesea 356676).

PL 3025, Lower part of cliff, Fishermans Steps, 1.5 km SW of Bird Rock, Torquay, Victoria, Inverleigh 632506, Jan Juc Formation, Late Oligocene, Janjukian (Yard grid ref. Anglesea 372697).

PL 3026, Left bank of Barwon River, 5.5 km S of Birregurra, Victoria, Colac 413473, Gellibrand Marl, Late Oligocene, Janjukian (Yard grid ref. Colac 863645).

PL 3027, South side of small gully about 300 m E of left bank of Moorabool River, about 20 m above river, allotment 13c Parish of Darriwill, Victoria, Bacchus Marsh 509931, Lower Maude Limestone, Late Oligocene, Janjukian (Yard grid ref. Meredith 237158).

PL 3028, Lower bed in cliff between Fossil Bluff and 1.5 km NW towards Table Cape, Wynyard, Tasmania, Table Cape 930630, Freestone Cove Sandstone, Early Miocene, early Longfordian (Yard grid ref. Table Cape 750530).

PL 3029, Upper bed in cliff between Fossil Bluff and 1.5 km NW towards Table Cape, Wynyard, Tasmania, Table Cape 930630, Fossil Bluff Sandstone, Early Miocene, early Longfordian (Yard grid ref. Table Cape 750530).

PL 3030, N slope, Cape Grim, 5.5 km NW of Woolnorth Homestead, Tasmania, Welcome 045939, Cape Grim Beds, Early Miocene, Longfordian.

PL 3031, Marl pit on Misery Knob about 0.8 km SW of Doctors Rocks and 0.4 km NW of Burnie sheet fossil locality, Wynyard, Tasmania, Hellyer 972585, Fossil Bluff Sandstone, Early Miocene, early Longfordian (Yard grid ref. Burnie 796480).

PL 3032, Cliff 30-40 m NE of Bird Rock at SW end of Jan Juc Beach, Torquay, Victoria, Inverleigh BT642519, Puebla Formation, Early Miocene, Longfordian (Yard grid ref. Anglesea 379706).

PL 3033, Cliff on left bank of Barwon River below golf course, Birregurra, Victoria, Colac 435522, Gellibrand Marl, Early Miocene, Longfordian (Yard grid ref. Colac 885701).

PL 3034, Surface material from slips on S bank of Lake Costin, 0.5 km W of Hordern Vale–Red Hill Road, Hordern Vale, Victoria, Princetown 156043, Fishing Point Marl, lower mollusc horizon, Early Miocene, Longfordian (Yard grid ref. Aire 363163).

PL 3035, Cliff section SE of Fischers Point about 10 m above Lake Craven, Hordern Vale, Victoria, Princetown 155040, Fishing Point Marl, lower mollusc horizon, Early Miocene, Longfordian (Yard grid ref. Aire 358159)

PL 3036, Cliff 30 m above Lake Craven, 0.4 km NW of Red Hill, Hordern Vale, Victoria, Princetown 156030, Fishing Point Marl, lower mollusc horizon, Early Miocene, Longfordian (Yard grid ref. Aire 359149).

PL 3037, Cutting on fence on N side of camping reserve, Hordern Vale, 0.4 km SW of Red Hill, Victoria, Princetown 156025, Fishing Point Marl, lower mollusc horizon, Early Miocene, Longfordian (Yard grid ref. Aire 358143).

PL 3038, G.S.V. loc. Ad14, shore platform 2.4 km N of Curlewis railway crossing, section 24, block 1, Parish of Moolap, Victoria, Portarlington 823733, Fyansford Formation, Early Miocene, Batesfordian (Yard grid ref. Portarlington 578937. Marked on Quarter sheet 23 SW).

PL 3039, G.S.V. loc. Ad12, shore platform, NE corner section 23, block 1, Parish of Moolap, Victoria, Geelong 807732, Fyansford Formation, Early Miocene, Batesfordian (Yard grid ref. Geelong 561936. Marked on Quarter sheet 23 SW).

PL 3040, Belmont shaft at 18 m at "New Geelong" between Colac Road and Germantown Road, close to the latter, Victoria, Fyansford Formation, Early Miocene, Batesfordian (Shaft sunk about 1891, probably in Allot. 9, Parish of Barrarbool).

PL 3041, G.S.V. loc. Fe20, bed 7, 20 m above flood plain, Amphitheatre, S of Bull Island, left bank of Yarrowee River, Victoria, Ballarat 615928, Fyansford Formation, Early Miocene, Batesfordian (Yard grid ref. Rokewood 058156).

PL 3042, Left bank of Yarrowee River (= Leigh) about 30 m above river, above prominent limestone bands, S of small gully, Victoria, Ballarat 605922, Fyansford Formation, Early Miocene, Batesfordian (Yard grid ref. Rokewood 050148).

PL 3043, Cutting on Lavers Hill–Cobden Road, 1.3 km S of Kennedys Creek, Victoria, Princetown 969253, Gellibrand Marl, Early Miocene, Batesfordian (Yard grid ref. Princetown 155390).

PL 3044, Chapple's locality, landslips on Latrobe Creek 1.2 km NW of Princetown, Victoria, Gellibrand Marl, Early Miocene, Batesfordian.

PL 3045, Cutting on Great Ocean Road, 0.8 km N of Princetown, Victoria, Princetown 877159, Gellibrand Marl, Early Miocene, Batesfordian (Yard grid ref. Princetown 053286).

PL 3046, Cutting on Lavers Hill–Cobden Road, 0.6 km S of Kennedys Creek, Victoria, Princetown 968256, Gellibrand Marl, Early Miocene, Batesfordian (Yard grid ref. Princetown 156395).

PL 3047, Cutting on Princetown–Simpson Road, 4.5 km N of Great Ocean Road, Victoria, Princetown 856211, Gellibrand Marl, Early Miocene, Batesfordian (Yard grid ref. Princetown 032348).

PL 3048, Cutting on Boornong (= Steens) Road, 2.1 km N of Cooriemungle Road, Cooriemungle, Victoria, Princetown 810337, Gellibrand Marl, Early Miocene, Batesfordian (Yard grid ref. Princetown 982485).

PL 3049, Cutting on SE side of Great Ocean Road, about 50 m NE of Serpentine (= Latrobe) Creek, Princetown, Victoria, Princetown 872149, Gellibrand Marl, Early Miocene, Batesfordian (Yard grid ref. Princetown 049278).

PL 3050, Top of section, close to Fischers Point, 25 m above Lake Craven, Hordern Vale, Victoria, Fishing Point Marl, Fishing Point Marl, upper mollusc horizon, Early Miocene, Batesfordian (Yard grid ref. Aire 352163).

PL 3051, Left bank of Glenelg River just above water level at S end of Devils Den, Myaring, Victoria, Dartmoor WD207188, Port Campbell Limestone, Myaring Member, Early Miocene, Longfordian.

PL 3052, G.S.V. loc. W/TM1, left bank of Moorabool River, 2.8 km S of Maude in small slip amphitheatre about 30 m above river, allot. 12a and 13c Parish of Darriwil, Victoria, Bacchus Marsh 510925, Upper Maude Limestone, Early Miocene, Longfordian (Yard grid ref. Meredith 238151. Quarter sheet 19 SW).

PL 3053, G.S.V. loc. W/TM2, left bank of Moorabool River, 3 km S of Maude, Victoria, Bacchus Marsh 511922, Upper Maude Limestone, Early Miocene, Longfordian (Yard grid ref. Meredith 239147. Marked on Quarter sheet 19 SW).

PL 3054, G.S.V. loc. F31, at water level in left bank of Mitchell River, Skinners, SW corner of allotment 29A1, Parish of Wuk Wuk., Victoria, Stratford 433167, Wuk Wuk Marl, Early Miocene, Batesfordian (Yard grid ref.

Stratford 439382. Marked on Wuk Wuk geological parish plan. Base of Wuk Wuk Marl).

PL 3055, Cliff and shore platform on south side of Golf Course, Flinders, Victoria, Western Port 268387, Flinders Limestone, Early Miocene, Batesfordian (Yard grid ref. Western Port 061553).

PL 3056, Cutting on Princetown-Simpson Road, 4 km N of Ocean Road, Victoria, Princetown 857210, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 033346).

PL 3057, Block 256 (S.M.Roberts) 6.5 km S of Simpson on Princetown Road, 2nd gully E of road approx., Victoria, Princetown 900334, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 082480).

PL 3058, Bend in Waarre Road, opposite old house, 1.2 km NE of Eastern Creek Road, Waarre, Victoria, Princetown 779270, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 948412).

PL 3059, Cutting on Great Ocean Road, 1.9 km NE of Princetown, Victoria, Princetown 884165, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 063297).

PL 3060, Dam on Lot 393 (A. Smith) in 2nd gully NE of house, tributary of Tomahawk Creek, Victoria, Princetown 968303, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 157454).

PL 3061, Slips in small gully on N side of Eastern Creek and 0.75 km E of Port Campbell Road, Victoria, Princetown 761278, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 928419).

PL 3062, Cutting on Cooriemungle Road, just S of Guys Road, 1.4 km NE of Gallum Road, Victoria, Princetown 861325, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 919425).

PL 3063, Cutting at junction of Ford Road and Latrobe Road, N of Princetown, Victoria, Princetown 888203, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 066335).

PL 3064, Cutting on Port Campbell-Timboon Road, 0.7–1.5 km N of Eastern Creek Road, Victoria, Princetown 752283, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 919425).

PL 3065, Cutting on Eastern Creek Road, 0.5 km E of Port Campbell Road, Victoria, Princetown 758273, Gellibrand Marl, Middle Miocene, Balcombian? (Yard grid ref. Princetown 924416).

PL 3066, Cutting on Port Campbell-Timboon road, 0.75 km S of Eastern Creek Road, Victoria, Princetown 749268, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 916408).

PL 3067, Low cliff immediately SE of rocks at SE end of Gibson Beach, 3.4 km NW of Point Ronald, Princetown, Victoria, Princetown 848162, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 027292).

PL 3068, Low cliff at SE end of Gibson Beach, 3.9 km NW of Point Ronald, Victoria, Princetown 846165, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 025295).

PL 3069, Cutting on Shelford-Inverleigh road, Red Bluff, 4.8 km N of Hamilton Highway, Victoria, Colac 616847, Fyansford Formation, Middle Miocene, Balcombian (Yard grid ref. Beeac 064066).

PL 3070, Cliff on left bank of Yarrowee (= Leigh) River at "Farrells", Allotment 44, Parish of Carrah, Victoria, Inverleigh 337823, Fyansford Formation, Middle Miocene, Balcombian (Yard grid ref. Geelong 090042).

PL 3071, 0–5 m in cliff on left bank of Native Hut Creek, 1 km SW of Glenleigh, Victoria, Inverleigh 454816, Fyansford Formation, Middle Miocene, Balcombian (Yard grid ref. Geelong 173034).

PL 3072, Approx. G.S.V. loc. Ad28, Orphanage Hill, Fyansford, Victoria, Geelong 648748, Fyansford Formation, Middle Miocene, Balcombian (Yard grid ref. Geelong 386956. Quarter sheet 24 SE (not marked)).

PL 3073, 12–15 m in a caisson shaft of SE Trunk Sewer on S side of Centre Dandenong Road, about 200 m E of Boundary Road, Dingley, Victoria, Newport Formation, Middle Miocene, Balcombian (Yard grid ref. Ringwood 148173).

PL 3074, 18–20 m in caisson shaft of SE Trunk Sewer, NE corner of Boundary Road and Junction Road, Dingley, Victoria, Newport Formation, Middle Miocene, Balcombian.

PL 3075, Spoil from SE Trunk Sewer between Brayside Shaft and shaft on S side of Centre Dandenong Road about 200 m E of Boundary Road, Dingley, Victoria, Newport Formation, Middle Miocene, Balcombian

PL 3076, Bed of Earimil (= Dennant) Creek about 50 m downstream from older volcanics, Victoria, Western Port 316724, Balcombe Clay, Middle Miocene, Balcombian (Yard grid ref. Cranbourne 120918).

PL 3077, Altona Bay Coal Shaft No.2 (1908), Victoria, Newport Formation, Middle Miocene, Balcombian.

PL 3078, Shore platform at Fossil Beach, 3 km S of Mornington, Victoria, Western Port 273658, Balcombe Clay, Middle Miocene, Balcombian (Yard grid ref. Cranbourne 072845).

PL 3079, Upstream section, Gunyoung (= Grices) Creek, Mt Eliza, Victoria, Western Port 311710, Balcombe Clay, Middle Miocene, Balcombian (Yard grid ref. Cranbourne 111910. Section 8A of Gostin (1966) *Proceedings of the Royal Society of Victoria* 79: 467).

PL 3080, 0–2 m above water on right bank of Moorabool River, NNW of Dryden Farm, Victoria, Geelong 637778, Fyansford Formation, Middle Miocene, Balcombian (Yard grid ref. Geelong 375990).

PL 3081, Clay overburden just above limestone, Australian Cement Quarry, right bank of Moorabool River, Batesford, Victoria, Geelong 625785 approx., Fyansford Formation, Middle Miocene, Balcombian (Yard grid ref. Geelong 360000 approx).

PL 3082, Clifton Bank, Muddy Creek, 7 km W of Hamilton, Victoria, Coleraine WD 818225, Muddy Creek Formation, Middle Miocene, Balcombian.

PL 3083, Top of Muddy Creek Formation on right bank of Muddy Creek about 100 m downstream from McDonalds Bank, Victoria, Coleraine WD 825219, Muddy Creek Formation, Middle Miocene, Balcombian.

PL 3084, Small gully 4.8 km S of Morgan Ferry–Cadell road on left bank of Murray River opposite Brenda Park Homestead, South Australia, Morgan 790280, Morgan

Limestone, Cadell Marl Lens, Middle Miocene, Balcombian (Renmark 1:250,000 sheet grid ref. 268789).

PL 3085, E and SE side of Lake Keilambete, Terang, Victoria, Mortlake 650688, Gellibrand Marl, Middle Miocene, Bairnsdalian (Yard grid ref. Mortlake 810868).

PL 3086, E bank of Lake Gnotuk, Camperdown, Victoria, Gellibrand Marl, Middle Miocene, Bairnsdalian.

PL 3087, NW shore of Lake Bullen Merri, Camperdown, Victoria, Corangamite 830653, Gellibrand Marl, Middle Miocene, Bairnsdalian.

PL 3088, NW end of Gibson Beach, 4.5 km NW of Point Ronald, Princetown, Victoria, Princetown 843168, Gellibrand Marl, Middle Miocene, Bairnsdalian (Yard grid ref. Princetown 022298).

PL 3089, Clay beneath limestone, cutting on track up to Victorian Agriculture Lime limestone quarry, Curdie, Victoria, Mortlake 709430, Gellibrand Marl, Middle Miocene, Bairnsdalian (Yard grid ref. Panmure 871589).

PL 3090, Cutting on Timboon–Scotts Creek Road, 2.4 km NE of Timboon, Victoria, Mortlake 740400, Gellibrand Marl, Middle Miocene, Bairnsdalian (Yard grid ref. Panmure 905554).

PL 3091, Large cutting opposite shops in Timboon, Victoria, Mortlake 727384, Gellibrand Marl, Middle Miocene, Bairnsdalian (Yard grid ref. Panmure 891536).

PL 3092, Cutting on Timboon–Port Campbell Road about 100 m S of Timboon shopping centre, Victoria, Mortlake 728382, Gellibrand Marl, Middle Miocene, Bairnsdalian (Yard grid ref. Panmure 893534).

PL 3093, G.S.V. loc. Aw10, 0–10 ft above HWL, Rutledges Beach, E side of the mouth of Rutledge Creek, Victoria, Princetown 783209, Port Campbell Limestone, Rutledge Creek Member, Middle Miocene, Bairnsdalian (Yard grid ref. Princetown 955345).

PL 3094, Notch at the Amphitheatre, mouth of Ingle Creek, Victoria, Princetown 779211, Port Campbell Limestone, Rutledge Creek Member, Middle Miocene, Bairnsdalian (Yard grid ref. Princetown 947346).

PL 3095, G.S.V. loc. Ad15, Western Beach, Corio Bay, Geelong, Victoria, Inverleigh 682754, Fyansford Formation, Middle Miocene, Bairnsdalian (Yard grid ref. Geelong 426960. Locality indicated on Quarter sheet 24 SE by Note 4).

PL 3096, 1–3 m above river in cliff, left bank of Yarrowee (= Leigh) River, due N of Inverleigh, Victoria, Inverleigh 420792, Fyansford Formation, Middle Miocene, Bairnsdalian (Yard grid ref. Geelong 138007).

PL 3097, 0–2 m above water, cliff on left bank of Barwon River, Section 2b, Parish of Murgheboluc, Victoria, Inverleigh 475776, Fyansford Formation, Middle Miocene, Bairnsdalian (Yard grid ref. Geelong 197988).

PL 3098, Right bank of Native Hut Creek, 100 m S of Hamilton Highway, Victoria, Inverleigh 459794, Fyansford Formation, Middle Miocene, Bairnsdalian (Yard grid ref. Geelong 181009).

PL 3099, 0–3 m in the cliff on the left bank of Barwon River about 500 m downstream from junction with Bruces Creek, Section 4a, Parish of Murgheboluc, Victoria, Inverleigh 462788, Fyansford Formation, Middle Miocene, Bairnsdalian (Yard grid ref. Geelong 184003).

PL 3100, 0–3 m in the cliff on the left bank of Barwon River about 500 m downstream from junction with Bruces Creek, Section 4a, Parish of Murgheboluc, Victoria, Inverleigh 503770, Fyansford Formation, Middle Miocene, Bairnsdalian (Yard grid ref. Geelong 229983).

PL 3101, Cliff, Moorpanyal Park, North Shore, Corio Bay, Geelong, Victoria, Geelong 696796, Fyansford Formation, Middle Miocene, Bairnsdalian (Yard grid ref. Geelong 007441).

PL 3102, Bed of Warrambine Creek, immediately downstream from Winchelsea–Inverleigh Road bridge, Victoria, Geelong 375769, Fyansford Formation, Middle Miocene, Bairnsdalian (Yard grid ref. Geelong 090982).

PL 3103, Downstream section at mouth of Gunyoung (= Grices) Creek, Mt Eliza., Victoria, Western Port 309712, Balcombe Clay, Middle Miocene, Bairnsdalian (Yard grid ref. Cranbourne 111910. Section 8B, beds a–f of Gostin (1966) *Proceedings of the Royal Society of Victoria* 79: 467).

PL 3104, Cliff section S of Manyung Rocks and N of sewer pipe and jetty, Mt Eliza, Victoria, Western Port 305705, Balcombe Clay, Middle Miocene, Bairnsdalian (Yard grid ref. Cranbourne 106903. Bed 10B(a) of Gostin (1966) *Proceedings of the Royal Society of Victoria* 79: 459–512).

PL 3105, Quarry in Allotment 15, Section A, Parish of Moormurng, 400 m W of Pleasant Creek, Hillside, East Gippsland, Victoria, Bairnsdale 455136, Gippsland Limestone, Bairnsdale Limestone Member, Middle Miocene, Bairnsdalian (Yard grid ref. Bairnsdale 463347).

PL 3106, Left bank, Nowa Nowa Arm of Lake Tyers, Victoria, Orbost 997177, Gippsland Limestone, Bairnsdale Limestone Member, Middle Miocene, Bairnsdalian (Yard grid ref. Hartland 055386).

PL 3107, McCraes Quarry, left bank of Toorloo Creek, Victoria, Orbost 913163, Gippsland Limestone, Bairnsdale Limestone Member, Middle Miocene, Bairnsdalian (Yard grid ref. Hartland 964372).

PL 3108, Cliff just beneath Bairnsdale Limestone, left bank Mitchell River, G.S.V. loc. F5O, 5l, SW corner of Allotment 15, Parish of Wy Yung (Driers), Victoria, Bairnsdale 501145, Wuk Wuk Marl, Middle Miocene, Bairnsdalian (Marked on Bairnsdale 1:63,36O Geological Sheet, grid ref. 513358. Top of Wuk Wuk Marl).

PL 3109, Right bank of Toorloo Arm of Lake Tyers, 0.5 km S of bridge, Victoria, Orbost 932141, Tambo River Formation?, Late Miocene, Mitchellian (Yard grid ref. Hartland 985347).

PL 3110, Large cutting on left bank of Tambo River, 200 m S of Princes Highway, Swan Reach, Victoria, Bairnsdale 759132, Tambo River Formation, Late Miocene, Mitchellian (Yard grid ref. Bairnsdale 795340).

PL 3111, Right bank of Mitchell River, Moondara Farm, about 50 m N of first gully SW of house (Rose Hill), Victoria, Bairnsdale 500132, Tambo River Formation, Rose Hill Marl Member, Late Miocene, Mitchellian (Yard grid ref. Bairnsdale 512344).

PL 3112, G.S.V. loc. F7l, right bank of Mitchell River, immediately SW of small gully on "Carinya", Victoria, Bairnsdale 503126, Tambo River Formation, Rose Hill Marl Member, Late Miocene, Mitchellian (Marked on Bairnsdale 1:63,36O Geological Sheet, grid ref. 514337).

PL 3113, Right bank of Nowa Nowa Arm of Lake Tyers, Victoria, Orbost 991153, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian? (Yard grid ref. Hartland 961302).

PL 3114, Cutting on Princes Highway, beds 6a,b, lowest shell bed and nearest bridge, NE side of Bunga Creek, Victoria, Orbost 911100, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Harland 961302).

PL 3115, Left bank of SE end of Lake Bunga near old trambridge (Lake Bunga Crossing), Victoria, Orbost 918085, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Hartland 967285).

PL 3116, Outcrop in road ditch, 20 m W of Lakes Entrance Development No.1 oil bore, right bank of Bunga Creek, Victoria, Orbost 912096, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Hartland 964298).

PL 3117, Cutting, Princes Highway, NE side of Bunga Creek, second lowest shell bed nearest bridge (bed b), Victoria, Orbost 911100, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Hartland 961302).

PL 3118, G.S.V. loc. F2, floor and sides of tramway cutting N of Scrivenors Road, Mississippi Creek, Victoria, Bairnsdale 836116, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Marked on Bairnsdale 1:63,360 Geological Sheet, grid ref. 878322. Same as PL532).

PL 3119, G.S.V. loc. F1, Ritchies Cutting, Scrivenors Road, W side of Mississippi Creek, Victoria, Bairnsdale 835114, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Marked on Bairnsdale 1:63,360 Geological Sheet, grid ref. 878329).

PL 3120, Cutting N side of John Street, Lakes Entrance, E of small gully, SE corner of allotment 30A, Section A, Parish of Colquhoun, Victoria, Bairnsdale 869075, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Bairnsdale 915275).

PL 3121, Shells in soil, 0–4 m above high water mark, right bank of North Arm at end of Hunters Road, Kalimna, Victoria, Bairnsdale 869075, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Bairnsdale 903288).

PL 3122, Bluff on W side North Arm, Kalimna, S of Hunters Gully, Victoria, Bairnsdale 865074, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Bairnsdale 909275).

PL 3123, Just below high tide level, E side of North Arm, on point below Ferndale Parade, Lakes Entrance, Victoria, Bairnsdale 867075, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Bairnsdale 913276).

PL 3124, Bluff on W side of North Arm, N side of Hunters Gully, Lakes Entrance, 0–1 m above high water mark, Victoria, Bairnsdale 864077, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Bairnsdale 909278).

PL 3125, Outcrop in road, 15.2 above water, E bank North Arm opposite end of Hunters Road, Lakes Entrance, Victoria, Bairnsdale 861087, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Bairnsdale 906289).

PL 3126, About 3 m above water on left bank of North Arm, below Nautilus Way, Lakes Entrance, Victoria, Bairnsdale 867080, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Bairnsdale 911282).

PL 3127, Shells loose in soil in tramway cutting, Mississippi Creek near terminus, Victoria, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian.

PL 3128, Cutting at bridge on farm track, right bank of first main northern tributary of Bunga Creek, SE corner, allotment 145, Parish of Colquhoun, Victoria, Orbost 897111, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Hartland 945318).

PL 3129, Sands exposed in sewer tunnel, 12.2 m below Wright Street, Bentleigh, between Centre Road and Beech Street, Victoria, Black Rock Sandstone, Late Miocene–Early Pliocene, Cheltenhamian.

PL 3130, Shelly clay at base of cliff at high tide mark opposite Dogtooth Beacon between Deauville Street and Hutchinson Avenue, Beaumaris, Victoria, Black Rock Sandstone, Late Miocene–Early Pliocene, Cheltenhamian.

PL 3131, Left bank Moorabool River, track on hillside about 300 m N of Moorabool Viaduct, Victoria, Geelong 616827, Moorabool Viaduct Sands, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Geelong 354045).

PL 3132, Bed of Spring Creek below tuff band, 800 m NE of Spring Creek Homestead, Minhamite, Victoria, Warrnambool 248925, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Hawkesdale 367129).

PL 3133, Left bank of River Murray at Wookool Bend about 3 m above water level, Loxton, South Australia, Renmark VG563869, Bookpurnong Beds, Late Miocene–Early Pliocene, Cheltenhamian.

PL 3134, Cutting behind Loxton Pumping Station, North Loxton, South Australia, Renmark VG623912, Loxton Sands, Pliocene, Kalimnan?

PL 3135, Cutting on Kingston–Loxton Road at Yatco Lagoon, 137 mile post, 10.0 km SE of Kingston, South Australia, Loxton Sands, Pliocene, Kalimnan? (Yard grid ref. Renmark 1:250,000 337763).

PL 3136, Cutting on Kingston–Loxton Road at Yatco Lagoon, 11.8 km SE of Kingston, South Australia, Loxton Sands, Pliocene, Kalimnan? (Yard grid ref. Renmark 1:250,000 336762).

PL 3137, Forsyths Bank, left bank of Grange Burn about 1 m above water level, Victoria, Coleraine WD832237, Grange Burn Formation, Early Pliocene, Kalimnan (See map by Spencer-Jones, in Wopfner and Douglas (eds). 1971. *The Otway Basin of southeastern Australia*. Special Bulletin Geol. Surveys S. Aust. Vict., figs 12–1, p. 243).

PL 3138, Bed of Grange Burn at the E end of "Porphry Gorge" by the "rock stack", Victoria, Coleraine WD837235, Grange Burn Formation, Early Pliocene, Kalimnan.

PL 3139, Bed of Muddy Creek at McDonalds Bank, Yulecart, Victoria, Coleraine WD826219, Grange Burn Formation, Early Pliocene, Kalimnan (See map by

Spencer-Jones, in Wopfner and Douglas (eds), 1971. *The Otway Basin of southeastern Australia*. Special Bulletin Geol. Surveys S. Aust. Vict., figs 12-1, p. 243).

PL 3140, Cutting on Princes Highway, bed 6d, NE side of Bunga Creek, Victoria, Orbost 912102, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Hartland 962303).

PL 3141, Cutting on Princes Highway, SW side of Bunga Creek, bed 5c, upper Jemmys Point shell bed, Victoria, Orbost 907097, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Hartland 956300).

PL 3142, Cutting on Princes Highway, NE side of Bunga Creek, bed 6g, uppermost shell bed, Victoria, Orbost 912103, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Hartland 963304).

PL 3143, Cliff on left bank of Nowa Nowa Arm of Lake Tyers, Victoria, Orbost 997132, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Hartland 056337).

PL 3144, Cliff section of S side of Lake Tyers Aboriginal Station, Victoria, Orbost 958111, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Hartland 012315).

PL 3145, Cliff on W bank of Lake Tyers, about 7 m above water, NE corner of allotment 6, section F, Parish of Colquhoun, Victoria, Orbost 948109, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Hartland 002313).

PL 3146, 3 m above water on E bank of Nowa Nowa Arm of Lake Tyers, 1 km NE of Tyers House, Victoria, Orbost 989121, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Hartland 047324).

PL 3147, G.S.V. loc. F7, shell bed in cliff behind Nyerimalang Jetty, about 3 m above high tide, Victoria, Bairnsdale 816072, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Hartland 857274. Marked on Colquhoun geological parish plan).

PL 3148, 0-4 m above high water mark in cliff E of Kalimna Jetty, Kalimna, Victoria, Bairnsdale 840070, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Bairnsdale 883271. Lower shell bed in Jemmys Point Formation).

PL 3149, Shell band exposed in cutting on Princes Highway, Jemmys Point, Victoria, Bairnsdale 850068, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Bairnsdale 895262).

PL 3150, Shell band about 7 m above high water mark in cliff on E side of Hopkins Bight, Nungurner, Victoria, Bairnsdale 789069, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Bairnsdale 826270).

PL 3151, Large cutting on Nyerimalang Estates Road, on right bank of Meringa Creek about 200 m S of Kalimna-Nungurner Road, Victoria, Bairnsdale 82507, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Bairnsdale 866279. Same as PL 531).

PL 3152, Ditch on E side of Kalimna-Nungurner Road about 100 m N of Bridge over Meringa Creek, Victoria, Bairnsdale 825082, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Bairnsdale 8662883).

PL 3153, Bed of Minnie Creek, allotment 27, Parish of Myaring, Victoria, Dartmoor WD218178, Whalers Bluff Formation, Late Pliocene-Pleistocene, Werrikooian.

PL 3154, Base of large quarry, right bank of Glenelg River, about 10 m above river, allotment 3, Parish of Wilkin, Victoria, Whalers Bluff Formation, Late Pliocene-Pleistocene, Werrikooian.

PL 3155, *Pecten* bed in grey sand, quarry on E side of McKinnon Road, about 1 km N of Myaring Bridge road., Victoria, Dartmoor WD220208, Whalers Bluff Formation, Crawford Member, Late Pliocene-Pleistocene, Werrikooian.

PL 3156, Loose shells in Glenelg River derived from slips at Roscoes Cliff, Victoria, Dartmoor WD225235, Whalers Bluff Formation, Late Pliocene-Pleistocene, Werrikooian.

PL 3157, Shells in sand about 7 m below *Pecten* bed at SW end of Roscoes Cliff on left bank of Glenelg River, Victoria, Dartmoor WD219223, Whalers Bluff Formation, Late Pliocene-Pleistocene, Werrikooian.

PL 3158, Loose shells at ford, left bank of Limestone Creek about 3 m above water level, 100 m upstream from Glenelg River, Victoria, Dartmoor WD203184, Whalers Bluff Formation, Late Pliocene-Pleistocene, Werrikooian.

PL 3159, Top of cliff at small gully, 4.8 km S of Morgan Ferry-Cadell road on left bank of Murray River, South Australia, Morgan 790280, Norwest Bend Formation, Pliocene (Renmark 1:250,000 sheet grid ref. 268789).

PL 3160, Quarry at top of cliff, right bank of Murray River, E side of approach to Cadell Ferry, South Australia, Morgan 858344, Norwest Bend Formation, Pliocene (Renmark 1:250,000 sheet grid ref. 275796).

PL 3161, Pit on S side of Runymede Road, about 3 km E of Runymede Station, Sandford., Victoria, Gellibrand Marl, Sandford Limestone Member, Early Miocene, Longfordian.

PL 3162, Cutting on corner of Melrose (= Seaview Range) Road and Cooriemungle Road, about 2 km W of Cooriemungle., Victoria, Princetown XC788311, Gellibrand Marl, Middle Miocene, Balcombian.

PL 3163, Cutting on Williams Road, 0.6 km E of Boornong Road junction, Cowleys Creek, Victoria, Coorangamite XC815374, Gellibrand Marl, Early Miocene, Batesfordian.

PL 3164, Western slope of Meanarra Hill, 5 km E of Kalbarri, Western Australia, Gantheaume KQ250330, Toolonga Calcilutite, Late Cretaceous, Santonian.

PL 3165, Large Main Road Department quarry, 16 km S of Madura Roadhouse, Roe Plain, Western Australia, Burnabbie 1:250,000 sheet grid ref. 315643, Roe Calcarenite, Late Pliocene.

PL 3166, Test pits on E side of access road to Hampton Microwave Repeater Tower, 2.5 km N of Hampton, Roe Plain, Western Australia, Eucla 1:250,000 sheet grid ref. 365465, Roe Calcarenite, Late Pliocene.

PL 3167, Pit 1.6 km N of Hampton Microwave Repeater Tower, Roe Plain, Western Australia, Eucla 1:250,000 sheet grid ref. 365464, Roe Calcarenite, Late Pliocene.

PL 3168, At type locality of Merlinleigh Sandstone and from W side of small mesa immediately to the SE on W side of fence, about 1.5 km SE of Merlinleigh Station,

Western Australia, Mt Sandiman LU175087, Merlinleigh Sandstone, Late Eocene (Type locality of Formation).
PL 3169, Small knoll about 1 km SE of the type locality of Merlinleigh Station and immediately E of NS boundary fence, Mount Sandiman Station, 2.8 km SE of Merlinleigh homestead site, Western Australia, Mt Sandiman LU183076, Merlinleigh Sandstone, Late Eocene.
PL 3170, In third gully S of track NW from Merlinleigh Station homestead, where track crosses escarpment, 2 km NNE of homestead site, Western Australia, Mt Sandiman LU165110, Merlinleigh Sandstone, Late Eocene.
PL 3171, Gravel scrape beside Thomson Highway, 23.5 km N of Highway 1, N of Walpole, Western Australia, Deep River 1:50,000 sheet grid ref. 743487, Pallinup Siltstone, Late Eocene (Silicified fossils weathered out in situ from Pallinup Siltstone).
PL 3172, Spoil from 10 m foundation holes for Hampton Microwave Repeater Tower, 53 km E of Madura and 6.3 km S of Eyre Highway, Roe Plain, Western Australia, Eucla 1:250,000 sheet CK365462, Roe Calcarenite, Late Pliocene (Yard grid ref. Eucla 563045).

Appendix 2

Species whose general anatomy has been examined by the author

Volutinae

Lyria mitraeformis, Fusivoluta clarkei

Family uncertain

Notovoluta verconis, N. gardneri, N. kreusleri, Volutoconus bednalli, V. grossi helenae

Amoriinae

Amoria grayi, A. undulata, A. macandrewi, A. damoni, A. exoptanda, A. molleri, A. canaliculata, A. zebra, A. "volva", A. hunteri, A. ellioti, Nannamoria inopinata, N. guntheri, N. amicula.

Zidoninae

Ericusa sowerbyi, E. papillosa, E. serricata, E. fulgetrum, Livonia mamilla, L. roadnightae, L. nodiplicata, Melo amphora, Alcithoe arabica, Cymbiola magnifica, C. sophia, C. pulchra, C. thatcheri, C. vespertilio, C. nivosa, C. aulica.

Plate 1

Figure 1. *Leptoscapha crassilabrum* (Tate), T622A, holotype, Muddy Creek, ×3.2.

Figures 2, 4. *Lyria acuticostulata* sp. nov., P31145, holotype, Fossil Beach, ×1.9.

Figures 3, 5. *Lyria acuticostulata* sp. nov., P31147, paratype, Fossil Beach, ×1.9.

Figure 6. *Lyria gemmata* Tate, T613, holotype, McDonalds Bank, ×1.2.

Figure 7. *Lyria harpularia* Tate, T395 A, holotype, Muddy Creek, ×1.4.

Figures 8, 9. *Leptoscapha crassilabrum* (Tate), P32207, hypotype Gunyoung Creek, ×2.9.

Figures 10, 11. *Mitreola salaputium* sp. nov., WAM 79.386, holotype, Mount Franklin Rd, W.A., ×3.8.

Figures 12, 20. *Lyria harpularia* Tate, P31878, hypotype, Muddy Creek, ×1.4.

Figures 13, 14. *Lyria gemmata* Tate, P31876, hypotype, Spring Creek, ×1.9.

Figures 15, 16. *Mitreola salaputium* sp. nov., P50007, paratype, Mount Franklin Rd, WA. ×3.8.

Figures 17, 19. *Lyria harpularia* Tate, P31150, hypotype, Muddy Creek, ×1.4.

Figure 18,. *Lyria semiacuticostata* Pritchard, P2733, hypotype, Table Cape, Tasm., ×1.4.

Plate 2

Figure 1. *Lyria mitraeformis* (Lamarck), SAM D10185, holotype of *Lyria kimberi* Cotton, Port Lincoln, SA ×1.9.

Figure 2. *Notovoluta saginata* (Finlay), Z185, holotype of *Voluta lirata* Johnston, Table Cape, Tasm, ×1.

Figure 3. *Notovoluta ellipsoidea* (Tate), T601A, hypotype, Muddy Creek, ×1.

Figure 4. *Notovoluta occidua* Cotton, D14500, holotype, Hopetoun, W.A., ×1.4.

Figure 5. *Notovoluta verconis* (Tate), WAM 776-69, hypotype, Yankalilla Bay, SA, ×1.9.

Figures 6, 7. *Lyria semiacuticostata* Pritchard, P2653, holotype, Table Cape, Tasm, ×2.0.

Figure 8. *Lyria acuticosta* Chapman, P13165, syntype, Ooldea Well, SA, ×1.4.

Figures 9, 10. *Scaphella (Aurinia) johannae* sp. nov., P41757, holotype, Browns Creek, ×1.2.

Figures 11, 12. *Scaphella (Aurinia) johannae* sp. nov. P41758, paratype, Browns Creek, ×1.9.

Figure 13. *Lyria acuticostata* Chapman, P13164, syntype, Ooldea Well, SA, ×1.3.

Figures 14, 15. *Notovoluta cathedralis* (Tate), P32213, hypotype, Clifton Bank, ×1.4.

Plate 3

Figures 1, 5. *Notovoluta lintea* (Tate), P32219, hypotype, S of Morgan, SA, ×1.9.

Figure 2. *Notovoluta ellipsoidea* (Tate), T601C, holotype, Muddy Creek, ×1.

Figures 3, 4. *Notovoluta linigera* sp. nov., P32218, paratype, SE of Fischer Point, ×1.4.

Figures 6, 10. *Notovoluta linigera* sp. nov. P32216, holotype; SE of Fischer Point ×1.9.

Figures 7, 9. *Notovoluta variculifera* sp. nov., P48599, holotype, Browns Creek, ×1.9.

Figures 8, 15. *Notovoluta capitonica* sp. nov., P32209, paratype, Browns Creek, ×1.9.

Figures 11, 12. *Notovoluta capitonica* sp. nov., P32210, paratype, Browns Creek, ×1.7.

Figures 13, 14. *Notovoluta variculifera* sp. nov., P48600, paratype, Browns Creek, ×1.9.

Plate 4

Figure 1 . *Notovoluta tabulata* (Tate), T611A, holotype, Tareena, NSW, ×1.4.

Figures 2, 4. *Notovoluta pseudolirata* (Tate), P32211, hypotype, Clifton Bank, ×1.1.

Figures 3, 5. *Notovoluta cathedralis* (Tate), T596B, holotype, Muddy Creek, ×1.5, ×1.

Figures 6, 10. *Notovoluta tabulata* (Tate), SAM P5740b, hypotype, Mindarie, SA, ×1.9.

Figure 7. *Notovoluta verconis* (Tate), D442, holotype, St Vincents Gulf, SA, ×1.5.

Figure 8. *Notovoluta tabulata* (Tate), SAM P5740a, hypotype, Mindarie SA, ×1.6.

Figure 9. *Notovoluta lintea* (Tate), T600, holotype, S of Morgan, SA, ×1.2.

Figures 11, 14. *Notovoluta differta* sp. nov., P32221, holotype, Kennedys Creek, ×1.4.

Figures 12, 13. *Notovoluta differta* sp. nov., P32222, paratype, Curlewis, ×1.4.

Plate 5

Figures 1, 7. *Notovoluta kreuslerae kreuslerae* (Angus), D8322, holotype of *Voluta rossiteri* Brazier, 1890, Lakes Entrance, ×0.7.

Figure 2. *Notovoluta pseudolirata* (Tate), T608C, holotype, Muddy Creek, ×1.1.

Figure 3. *Notovoluta verconis* (Tate), WAM 776-69, Yankalilla Bay, SA, ×1.5.

Figures 4, 5. *Notovoluta ellipsoidea* (Tate), P13250, holotype of *Voluta (Aulica) sexuaplicata* Chapman, 1922, Clifton Bank, ×1.

Figures 6, 13. *Notovoluta baconi* Wilson, WAM 1565-70, holotype, W of Wedge Is., WA, ×1.2.

Figure 8. *Notovoluta saginata* (Finlay), TM 1072, holotype, Table Cape, ×1.1.

Figure 9. *Notovoluta occidua* Cotton, D14500, holotype, Hopetoun, WA, ×1.5.

Figures 10, 11. *Notovoluta pseudolirata* (Tate), WAM 131-64, hypotype, W of Rottnest Is., WA, ×1.6.

Figure 12. *Notovoluta pseudolirata* (Tate), WAM 470-71, hypotype, NW of Rottnest Isl. WA, ×1.5.

Plate 6

Figures 1, 2. *Amoria undulata undulata* (Lamarck), P6593, hypotype, Jemmys Point, ×0.7.

Figures 3, 7. *Amoria undulata undulata* (Lamarck), P34267, hypotype, Rose Hill, ×1.

Figure 4. *Amoria costellifera* (Tate), T603, holotype, Muddy Creek, ×1.

Figures 5, 9. *Amoria undulata masoni* (Tate), P34263, hypotype, McDonalds Bank, ×0.8 (Fig. 5 specimen uncoated).

Figure 6. *Amoria undulata masoni* (Tate), T385A, lectotype, Muddy Creek, ×1.

Figure 8. *Amoria costellifera* (Tate), T597B, holotype of *Nannamoria absidata* Cotton, 1949, Muddy Creek, ×1.

Figures 10–12. *Amoria costellifera* (Tate), P34261, hypotype, Clifton Bank, ×1. (Fig. 12, specimen uncoated).

Plate 7

Figures 1, 4. *Nannamoria deplexa* sp. nov., P32922, holotype, Bornong Rd, ×1.8.

Figures 2, 3. *Nannamoria amplexa* sp. nov., P33072, paratype, Ferndale Parade, ×1.4.

Figures 5, 7. *Nannamoria weldii* (Tenison Woods), Z191, holotype, Table Cape, ×1.4.

Figure 6. *Nannamoria amplexa* sp. nov., P33071, paratype, Ferndale Parade, ×1.4.

Figure 8. *Nannamoria limbata* (Tate), T590A, holotype, Mornington, ×1.4.

Figures 9, 11. *Nannamoria limbata* (Tate) P33088, hypotype, Gunyoung Creek, ×1.4.

Figure 10. *Nannamoria fasciculata* sp. nov., P32916, paratype, SE of Fischers Point, ×1.4.

Figures 12, 13. *Nannamoria stolida* (Johnston), P32910, hypotype, Table Cape, ×1.

Figures 14, 15. *Nannamoria stolida* (Johnston), Z186, holotype, Table Cape, ×1.

Plate 8

Figures 1, 4. *Nannamoria strophodon strophodon* (McCoy), P12153, paratype, Lake Bullenmerri?, ×1.6.

Figures 2, 3. *Nannamoria capricornea* (Wilson), WAM 774-71, paratype, W of Point Cloates, WA, ×1.9.

Figures 5, 8. *Nannamoria strophodon strophodon* (McCoy), P12154, holotype, Curlewis, ×2.1.

Figures 6, 7. *Nannamoria strophodon strophodon* (McCoy), P26388, paratype, Fyansford, ×1.7.

Figures 9, 11. *Nannamoria strophodon strophodon* (McCoy), P26389, paratype, Fyansford, ×1.8.

Figure 10. *Nannamoria capricornea* (Wilson), WAM 146-64, holotype, W of Point Cloates, WA, ×1.8.

Plate 9

Figures 1, 5. *Nannamoria ralphi* (Finlay), P33074, hypotype, Clifton Bank, ×1.4.

Figures 2, 3. *Nannamoria stolida* (Johnston), P2534, hypotype, Table Cape, ×1.

Figures 4, 8. *Nannamoria ralphi* (Finlay), P33076, hypotype, Clifton Bank, ×1.4.

Figures 6, 7. *Nannamoria paraboloides* sp. nov., P52308, paratype, Meringa Creek, ×1.4.

Figures 9, 12. *Nannamoria amplexa* sp. nov., P33069, holotype, Ferndale Parade, ×1.9.

Figures 10, 11. *Nannamoria limbata* (Tate), P33086, hypotype, Manyung Rocks, ×1.4.

Plate 10

Figures 1, 2. *Nannamoria weldii* (Tenison Woods), MUGD 1794, holotype of *Voluta weldii* var.. *angustior* Pritchard, 1913, Table Cape, ×1.9.

Figure 3. *Nannamoria ralphi* (Finlay), T588A, holotype, Muddy Creek, ×1.2.

Figure 4. *Nannamoria strophodon guntheri* (Smith), D13517, holotype of *Voluta adcocki* Tate, 1889, St Vincents Gulf, SA, ×1.

Figures 5, 6. *Nannamoria deplexa* sp. nov., P32924, paratype, Bornong Rd, ×1.9.

Figure 7. *Nannamoria paraboloides* sp. nov., P33077, holotype Spring Creek, ×1.8.

Figure 8. *Nannamoria paraboloides* sp. nov., P33079, paratype, Lot 47, Furneaux Estate, Tas. ×1.9.

Figures 9, 10. *Nannamoria fasciculata* sp. nov., P32915, holotype, SE of Fischer Point, ×1.4.

Figure 11. *Nannamoria fasciculata* sp. nov., P32916,

paratype, SE of Fischer Point, ×1.4.

Figure 12. *Nannamoria amplexa* sp. nov., P33071, paratype, Ferndale Parade, ×1.4.

Plate 11

Figures 1, 4. *Nannamoria trionyma* sp. nov., P32920, holotype, Clifton Bank, ×1.7.

Figure 2. *Nannamoria paraboloides* sp. nov., P33077, holotype, Spring Creek, ×1.8.

Figure 3. *Nannamoria paraboloides* sp. nov., P33079, paratype, Lot 47, Furneaux Estate, Tasm., ×1.9.

Figures 5, 8. *Nannamoria deplexa* sp. nov., P32923, paratype, Bornong Rd, ×1.8.

Figures 6, 7. *Nannamoria trionyma* sp. nov., P32918, paratype, Clifton Bank, ×1.7.

Figures 9, 12. *Nannamoria cinctuta* sp. nov., P33081, holotype, Block 22, Furneaux Estate, Tasm., ×1.2.

Figures 10, 11. *Nannamoria cinctuta* sp. nov., P33082, paratype, Block 22, Furneaux Estate, Tas., ×1.2.

Plate 12

Figures 1, 4. *Alcithoe (Waihaoia) pagodoides pagodoides* (Tate), P34821, hypotype, Blanche Point, SA, ×1.4.

Figures 2, 3. *Alcithoe (Waihaoia) pagodoides sororcula* subsp. nov., P37630, holotype, Bird Rock, ×1.7.

Figures 5, 9. *Alcithoe (Waihaoia) neglectoides* sp. nov., P37627, paratype, Bird Rock, ×1.4.

Figures 6, 8. *Alcithoe (Waihaoia) pagodoides sororcula* subsp. nov., P37631, paratype, Bird Rock, ×1.8.

Figure 7. *Alcithoe (Waihaoia) pagodoides pagodoides)* (Tate), T610B, holotype, Blanche Point, SA, ×1.4

Figures 10, 13. *Alcithoe (Waihaoia) pagodoides pagodoides* (Tate), P34822, hypotype, Browns Creek, ×1.4.

Figures 11, 12. *Alcithoe (Waihaoia) neglectoides* sp. nov., P37628, holotype, Bird Rock, ×1.4.

Plate 13

Figure 1. *Alcithoe (Waihaoia) cribrosa* (Tate), P34825, hypotype, Browns Creek, ×1.4.

Figures 2, 3. *Alcithoe (Waihaoia) cribrosa* (Tate), P34824, hypotype, Blanche Point, SA, ×1.4.

Figure 4. *Alithoe (Waihaoia) cribrosa* (Tate), T605A, lectotype, Blanche Point, SA, ×1.5.

Figure 5. *Alcithoe (Waihaoia) sarissa* (Tate), P38303, hypotype, Clifton Bank, ×1.

Figures 6, 8. *Alcithoe (Alcithoe) macrocephala* (Finlay), SAM P5755, hypotype, Murray Plains, SA, ×1.4.

Figure 7. *Alcithoe (Alcithoe) macrocephala* (Finlay), T389, holotype, Tareena, NSW, ×1.

Figures 9, 12. *Alcithoe (Alcithoe) orphanata* sp. nov., P37636, paratype, Block 22, Furneaux Estate, Tas., ×0.7.

Figures 10, 11. *Alcithoe (Alcithoe) orphanata* sp. nov., P37635, holotype, Block 22, Furneaux Estate, Tas., ×0.7.

Plate 14

Figures 1, 8. *Alcithoe (Waihaoia) pueblensis* (Pritchard), MUGD 1806, holotype, Bird Rock, ×1.5.

Figures 2, 3. *Alcithoe (Waihaoia) pueblensis* (Pritchard), P12773, hypotype, Bird Rock, ×1.

Figures 4, 12. *Alcithoe (Waihaoia) tateana* (Johnston), P2587, hypotype, Table Cape, Tas., ×1.2.

Figure 5. *Alcithoe (Waihaoia) sarissa* (Tate), P38303, hypotype,, Clifton Bank, ×1.

Figures 6, 7. *Alcithoe (Waihaoia) tateana* (Johnston), Z187, holotype, Table Cape, Tas., ×1.

Figures 9, 10. *Alcithoe (Waihaoia) pueblensis* (Pritchard), P34842, hypotype, Bird Rock, ×1.4.

Figure 11. *Alcithoe (Waihaoia) sarissa* (Tate), T578A, lectotype, Muddy Creek, ×1.

Plate 15

Figures 1, 2. *Ericusa macroptera* (McCoy), P48588, hypotype, Spring Creek, Torquay, ×0.6.

Figures 3, 5. *Ericusa ancilloides* (Tate), P41730, hypotype, Red Bluff, Shelford, ×1.

Figure 4. *Ericusa ancilloides* (Tate), T396D, lectotype, Mornington, ×1.

Figures 6, 9. *Ericusa hamiltonensis* (Pritchard), P12566, hypotype, Muddy Creek, ×0.7.

Figures 7, 8. *Ericusa sowerbyi pellita* (Johnston), P41709, hypotype, lower bed, Table Cape, Tas., ×0.5.

Plate 16

Figures 1, 3. *Ericusa sowerbyi sowerbyi* (Kiener), P41732, hypotype, Block 22, Furneaux Estate, Flinders Is., Tas., ×0.6.

Figures 2, 7. *Ericusa sowerbyi sowerbyi* (Kiener), P41731, hypotype, Meringa Creek, ×0.7.

Figures 4, 5. *Ericusa sowerbyi pellita* (Johnston), P41710, hypotype, upper bed, Table Cape, Tas., ×0.5.

Figures 6, 8. *Ericusa fulgetroides* (Pritchard), P7843, hypotype, McDonalds, Muddy Creek, ×0.7.

Plate 17

Figures 1, 2. *Ericusa macroptera* (McCoy), P12379, lectotype, Bird Rock Cliffs, ×0.7.

Figure 3. *Ericusa sowerbyi sowerbyi* (Kiener), SAM D14625, holotype of *Mesericusa stokesi* Cotton, Beachport, SA, ×0.7.

Figures 4, 5. *Ericusa sowerbyi pellita* (Johnston), MUGD 1789, holotype of *Voluta halli* Pritchard, Spring Creek, ×0.7.

Plate 18

Figures 1,6. *Ericusa fulgetroides* (Pritchard), MUGD 1804, holotype, Grange Burn, ×0.7.

Figures 2,7. *Ericusa hamiltonensis* (Pritchard), MUGD 1832, holotype, lower beds, Muddy Creek, ×0.7.

Figure 3. *Ericusa macroptera* (McCoy), P12378, paralectotype, Bird Rock Cliffs, ×0.7.

Figures 4, 5. *Ericusa sowerbyi pellita* (Johnston), Z156, holotype, Table Cape, Tas., ×0.7.

Figures 8. *Ericusa sowerbyi sowerbyi* (Kiener), SAM D14625, holotype of *Mesericusa stokesi* Cotton, ×0.7.

Plate 19

Figures 1, 2. *Livonia voluminosa* sp. nov., P41368, holotype, lower bed, Table Cape, Tas., ×0.6.

Figures 3, 5. *Ericusa atkinsoni* (Pritchard), P41723, hypotype, lower bed, Table Cape, Tas., ×0.6.

Figures 4, 6. *Livonia voluminosa* sp. nov., P2986, para-

type, lower bed, Table Cape, Tas., ×0.5.

Plate 20

Figures 1, 3. *Ericusa atkinsoni* (Pritchard), P2985, holotype, Table Cape, Tas., ×0.7.

Figures 2, 4. *Livonia gatliffi* (Pritchard), MUGD 1805, lower beds, Muddy Creek, ×1.

Figures 5, 6. *Livonia hannafordi* (McCoy), P12155, lectotype, foot of Mt Eliza, ×0.7.

Plate 21

Figures 1, 3. *Livonia gatliffi* (Pritchard), P41472, hypotype, Muddy Creek, ×1.

Figures 2, 5. *Livonia heptagonalis* (Tate), P13895, hypotype, S of Morgan, SA, ×0.5.

Figures 4, 6. *Livonia hannafordi* (McCoy), P12972, hypotype, Muddy Creek, ×0.31.

Plate 22

Figures 1, 2. *Livonia mortoni mortoni* (Tate), P2571, hypotype, lower bed, Table Cape, Tas., ×1.

Figures 3, 4. *Livonia mortoni mortoni* (Tate), Z208, holotype, lower bed, Table Cape, Tas., ×1.4.

Figure 5. *Livonia hannafordi* (McCoy), T392, holotype of *Voluta alticostata* Tate, Muddy Creek, ×1.

Figures 6, 7. *Livonia mortoni connudata* sp. nov., P41558, holotype, Muddy Creek, ×1.

Plate 23

Figures 1, 3. *Livonia stephensi* (Johnston), P41366, hypotype, Table Cape, Tas., ×0.7.

Figure 2. *Livonia spenceri* (Pritchard), P2990, holotype, Table Cape, Tas., ×1.1.

Figure 5. *Livonia stephensi* (Johnston), P41367, hypotype, lower bed, Table Cape, Tas., ×0.9.

Figures 4, 6. *Livonia stephensi* (Johnston), Z183, holotype, Table Cape, Tas., ×1.

Plate 24

Figure 1. *Livonia heptagonalis* (Tate), T397A, lectotype, S of Morgan, SA, ×1.

Figure 2. *Livonia heptagonalis* (Tate), T397C, paralectotype, S of Morgan, SA, ×1.

Figure 3. *Cymbiola macdonaldi* (Tate), T381A, hypotype, Muddy Creek, ×1.

Figure 4. *Cymbiola uncifera* (Tate), T394B, lectotype, S of Morgan, SA, ×1.4.

Figure 5. *Livonia spenceri* (Pritchard), P2990, holotype, Table Cape, Tasm., ×1.1.

Figure 6. *Cymbiola macdonaldi* (Tate), T381D, holotype, Mornington, ×1.3.

Figure 7. *Cymbiola uncifera* (Tate), T394A, paralectotype, S of Morgan, SA, ×1.4.

Plate 25

Figures 1, 2. *Notopeplum primarugatum* sp. nov., P31159, paratype, Point Flinders, ×1.9.

Figures 3, 4. *Notopeplum primarugatum* sp. nov., P31158, holotype, Point Flinders, ×2.

Figure 5. *Notopeplum annulatum* Wilson, WAM 132-64, holotype, W of Rottnest I, WA, ×1.6.

Figure 6. *Notopeplum primarugatum* sp. nov., P31160, paratype, Point Flinders, ×1.9.

Figure 7. *Notopeplum protorhysum* (Tate), T589A, lectotype, Kent Town Bore, SA, ×1.4.

Figure 8. *Nofopeplum politum* (Tate), T602A, lectotype, Muddy Creek, ×1.2.

Figure 9, 12. *Notopeplum politum* (Tate), P31164, hypotype, Clifton Bank, Muddy Creek, ×1.9.

Figures 10, 11. *Notoeplum protorhysum* (Tate), P31155, hypotype, Blanche Point, SA, ×1.9.

Plate 26

Figures 1, 6. *Notopeplum mccoyi mccoyi* (Tenison Woods), P31162, hypotype, Table Cape, Tas., ×1.9.

Figures 2, 3. *Notopeplum mccoyi translucidum* (Verco), D15013, hypotype, W of Eucla, WA, ×1.4.

Figures 4, 5. *Notopeplum mccoyi translucidum* (Verco), P31163, hypotype, Clifton Bank, Muddy Creek, ×1.1.

Figures 7, 8. *Notopeplum mccoyi translucidum* (Verco), TM 1071, holotype of *Notopeplum balcombensis* Finlay, Balcombe Bay, ×1.4.

Figures 9, 13. *Notopeplum mccoyi translucidum* (Verco), D13614 holotype, off Newland Head, SA, ×1.4.

Figure 10. *Notopeplum annulatum* Wilson, WAM 132-64, holotype, W of Rottnest Is., WA, ×1.6.

Figures 11, 12. *Notopeplum mccoyi mccoyi* (Tenison Woods), P31161, hypotype, Table Cape, Tas., ×1.9.

Plate 27

Figures 1, 4. *Notovoluta capitonica* sp. nov., P126803, holotype, Brown Creek, ×1.

Figures 2, 3. *Leptoscapha crassilabrum* (Tate), F53231, Gleesons Landing, SA, ×3.8.

Figures 5, 9. *Leptoscapha crassilabrum* (Tate), F53232, Gleesons Landing, SA, ×3.8.

Figures 6, 8. *Leptoscapha crassilabrum* (Tate), F53234, Gleesons Landing, SA, ×2.9.

Figures 7, 10. *Leptoscapha crassilabrum* (Tate), F53233, Gleesons Landing, SA ×2.9.

Figures 11, 14. *Notovoluta gardneri* Darragh, Mo11579, E. of Lady Musgrave Island, Qld, ×1.

Figures 12, 13. *Nannamoria inopinata* Darragh, C108644a, holotype, 42 km NE of Lady Musgrave Island, Qld, ×1.2.

Plate 28

Figures 1, 2. *Lyria gracilicostata* Ludbrook, P56032, hypotype, 1.5km N. of Hampton Tower, WA, ×1.4.

Figures 3, 4. *Lyria gracilicostata* Ludbrook, P56031, hypotype, 1.5 km N. of Hampton Tower, WA, ×1.

Figures 5, 6. *Lyria gracilicostata* Ludbrook, GSWA F 6951, holotype, 21 km NE of Eyre, WA, ×1.1.

Figures 7, 8. *Lyria mitraeformis crassicostata* subsp. nov., WAM 79.404 b, paratype, 1.5 km N. of Hampton Tower, WA, ×1.2.

Figures 9, 10. *Lyria mitraeformis crassicostata* subsp. nov., WAM 79.396a, holotype, 1.5 km N. of Hampton Tower, WA, ×1.

Figures 11, 12. *Lyria mitraeformis crassicostata* subsp. nov., P56034, paratype, 1.5 km N of Hampton Tower, WA, ×1.2.

Plate 29

Figures 1, 2. *Notovoluta verconis medicata* subsp. nov., WAM 76.2399, paratype, Quarry N of Hampton Tower, WA, ×1.4.

Figures 3, 4. *Notovoluta verconis medicata* subsp. nov., P59665, paratype, Hampton Tower, WA, ×1.4.

Figures 5, 6. *Notovoluta verconis medicata* subsp. nov., WAM 79.2595, holotype, 1.5 km N of Hampton Tower, WA, ×1.4.

Figures 7, 10. *Amoria exoptanda* (Reeve), WAM 79.394a, hypotype, 1.5 km N of Hampton Tower, WA, ×0.7.

Figures 8, 9. *Nannamoria lundeliusae* Ludbrook, WAM 76.2389a, hypotype, Access road to Hampton Tower, WA, ×1.2.

Figures 11, 12. *Notovoluta kreuslerae occulta* subsp. nov., WAM 76.2476, paratype, Hampton Tower, WA, ×1.

Figures 13, 14. *Notovoluta kreuslerae occulta* subsp. nov., WAM 79.389a, holotype, 1.5 km N of Hampton Tower, WA, ×1.

Plate 30

Figures 1, 2. *Ericusa subtilis* (Ludbrook), WAM 79.391, hypotype, 1.5 km N of Hampton Tower, WA, ×1.

Figures 3, 4. *Ericusa subtilis* (Ludbrook), WAM 69.515, holotype, Hampton Tower, WA, ×1.

Figures 5, 6. *Nannamoria lundeliusae* Ludbrook, WAM 72.26, paratype Quarry N of Hampton Tower, WA, ×1.3.

Figure 7. *Ericusa fulgetrum* (G.B. Sowerby I), WAM 79.410, hypotype, Pit, Eyre Highway, 6.3 km E of Hampton Tower Road, WA ×0.7.

Figures 8, 9. *Livonia stephensi* (Johnston), A.I.M. TM 839, ×1.

PLATE 1


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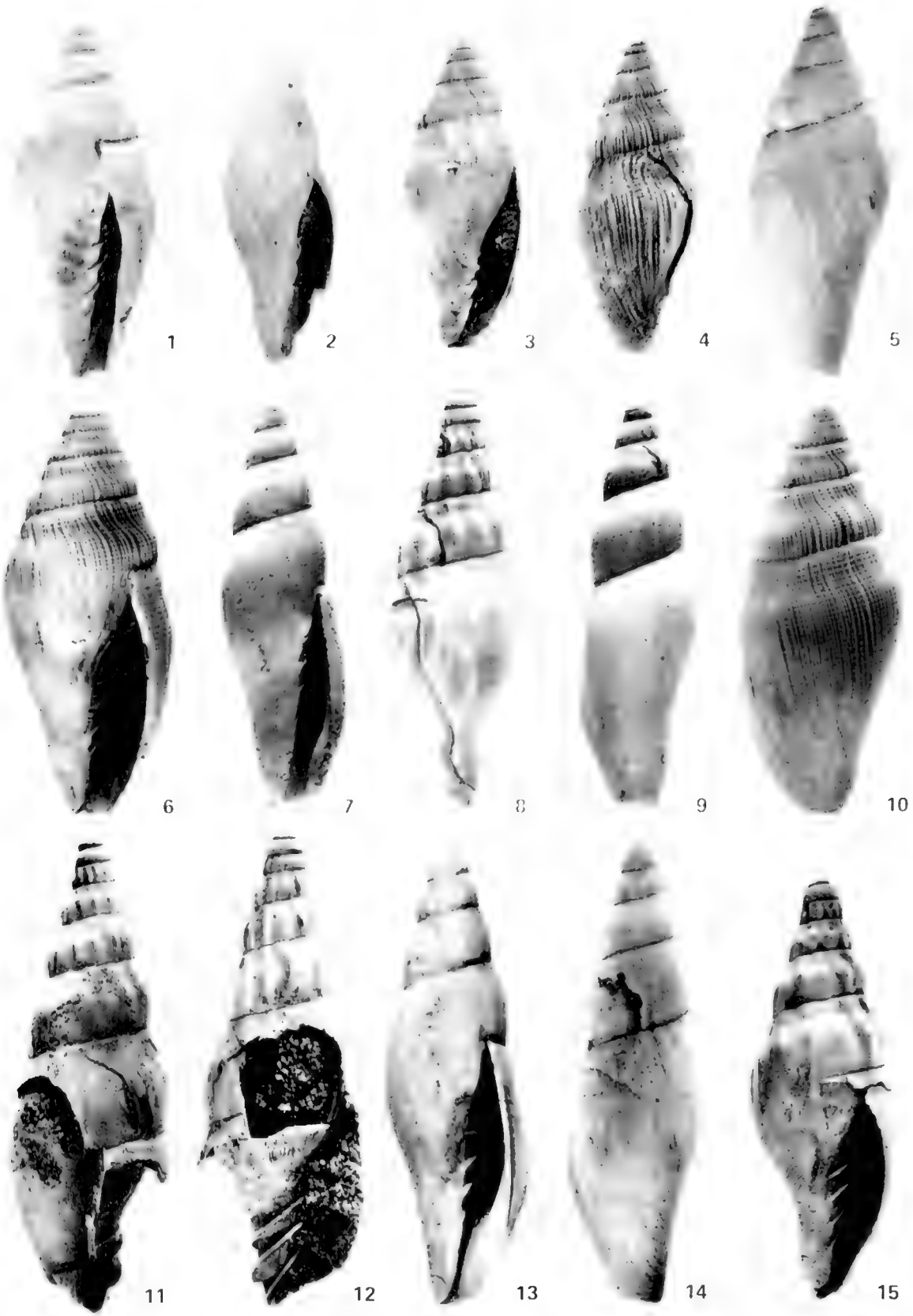
PLATE 3

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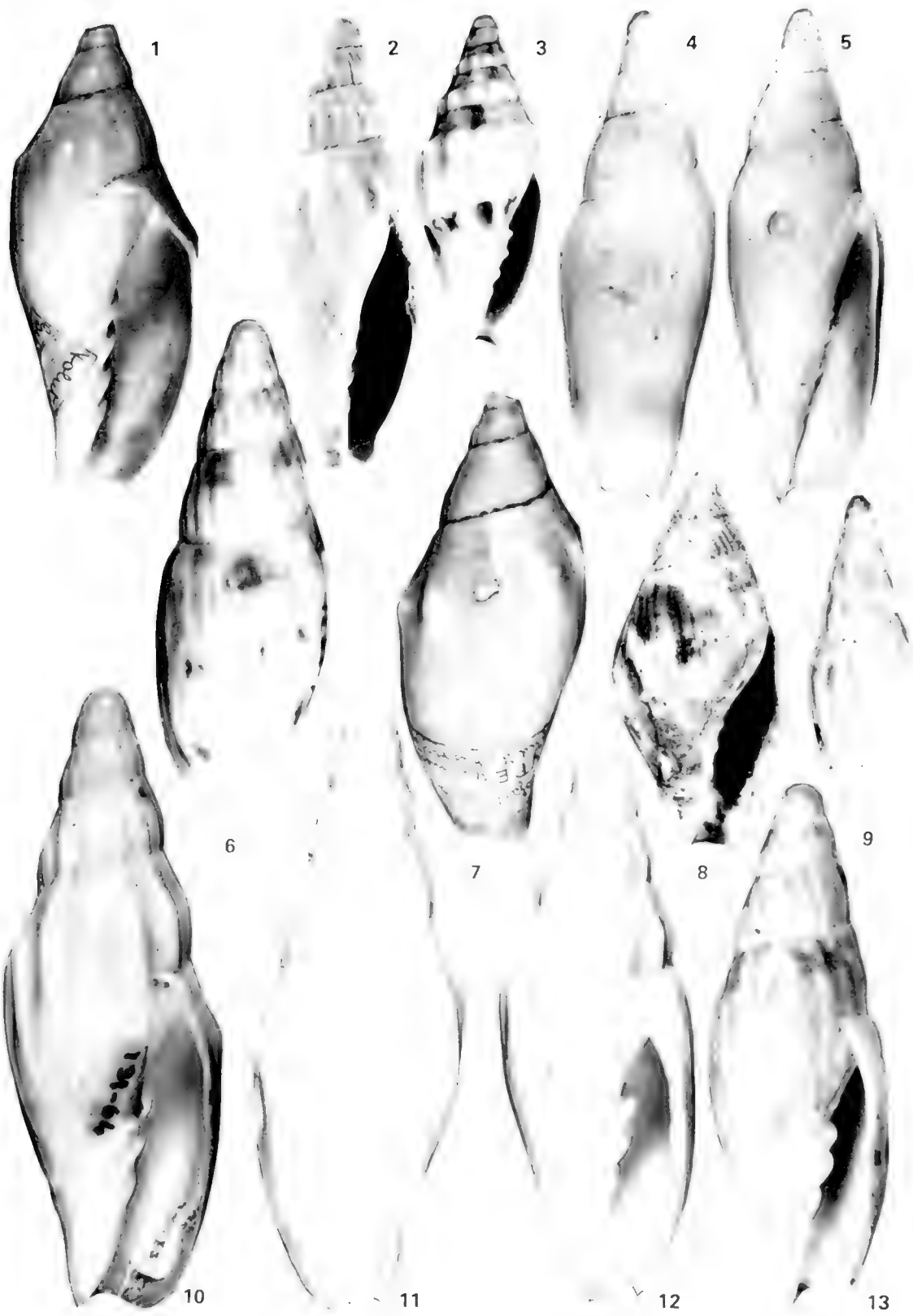


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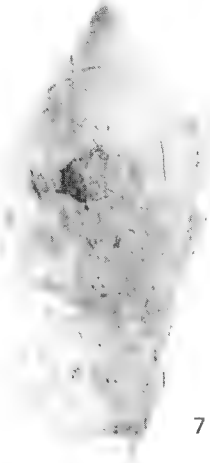
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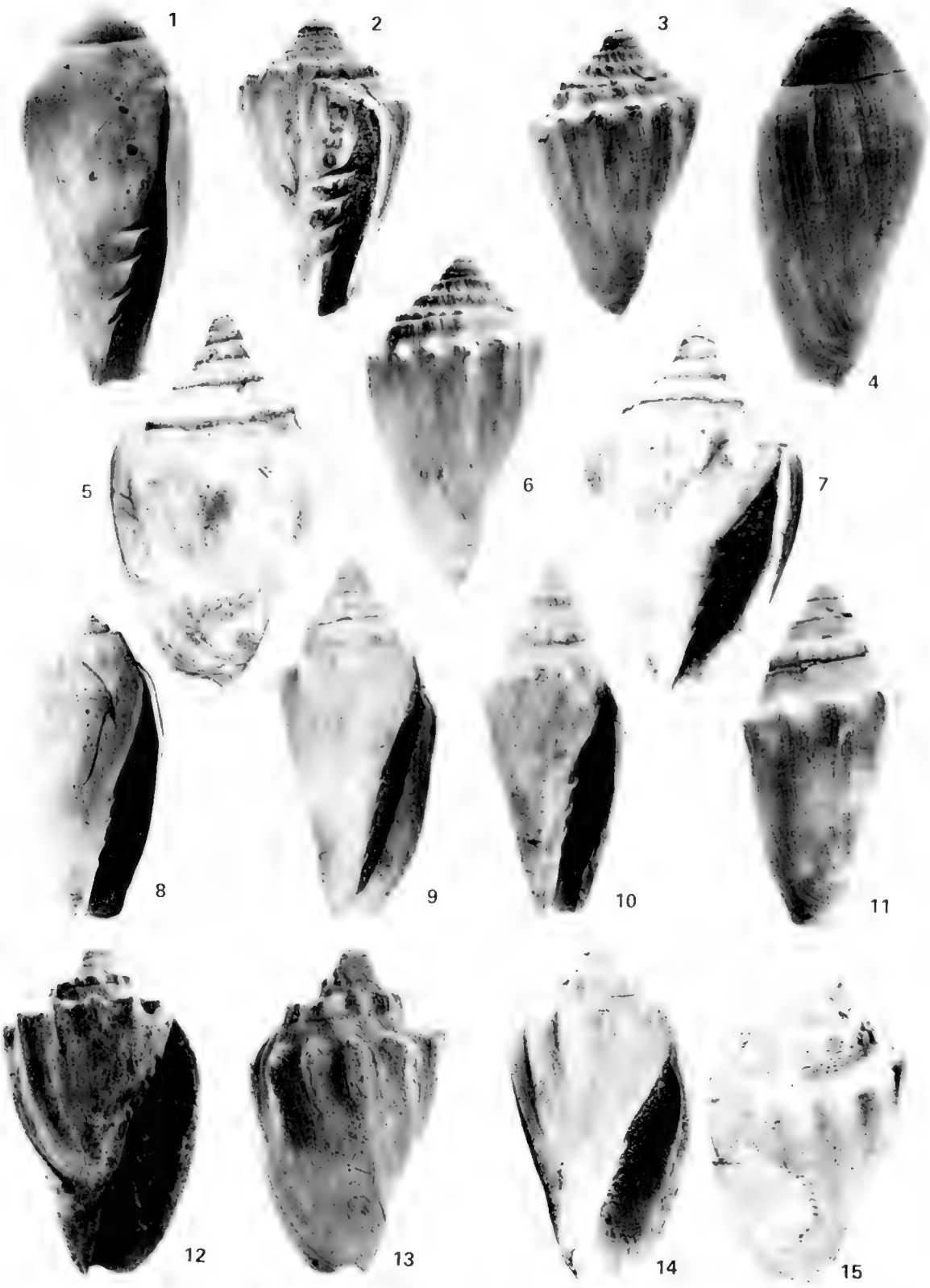

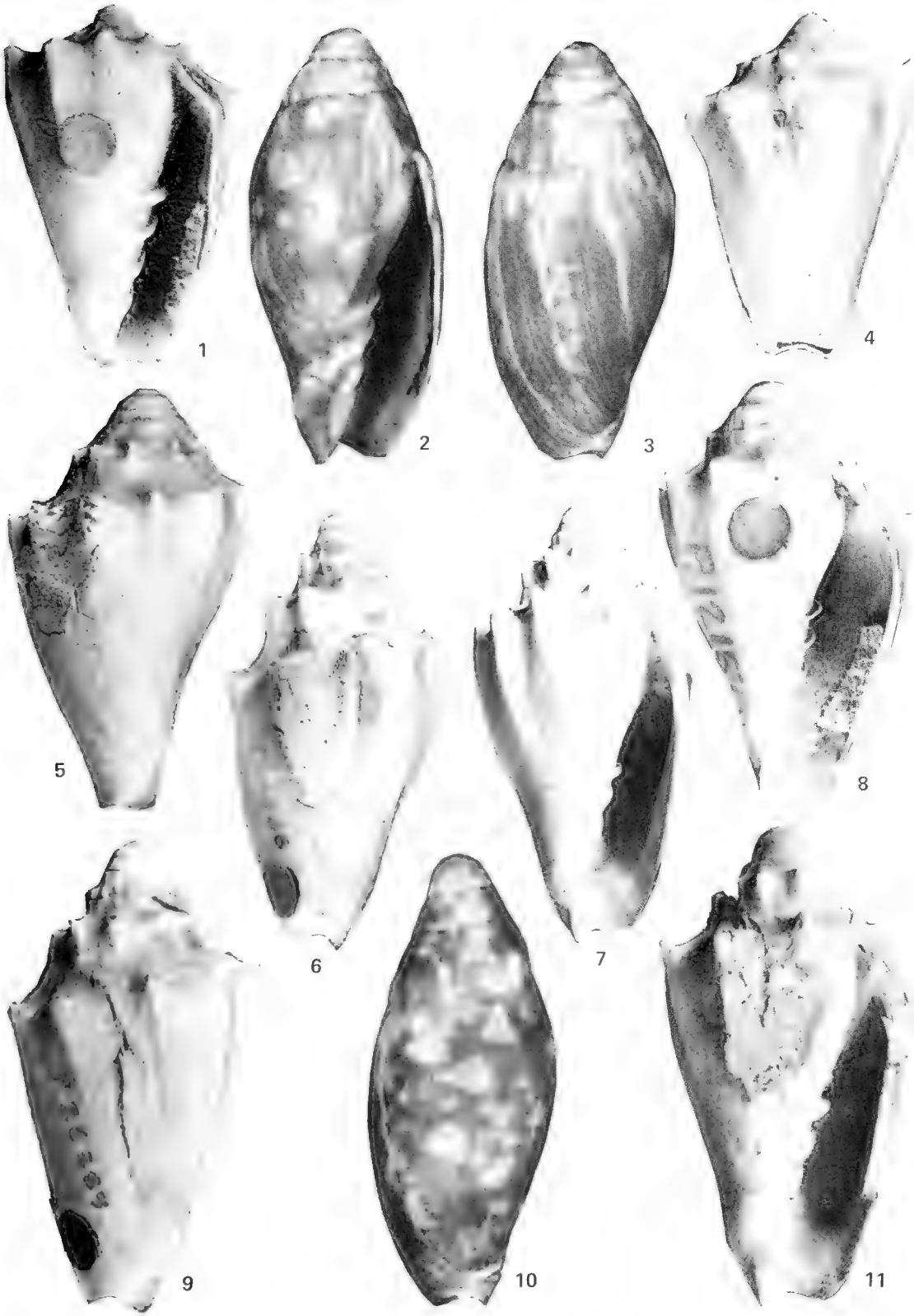
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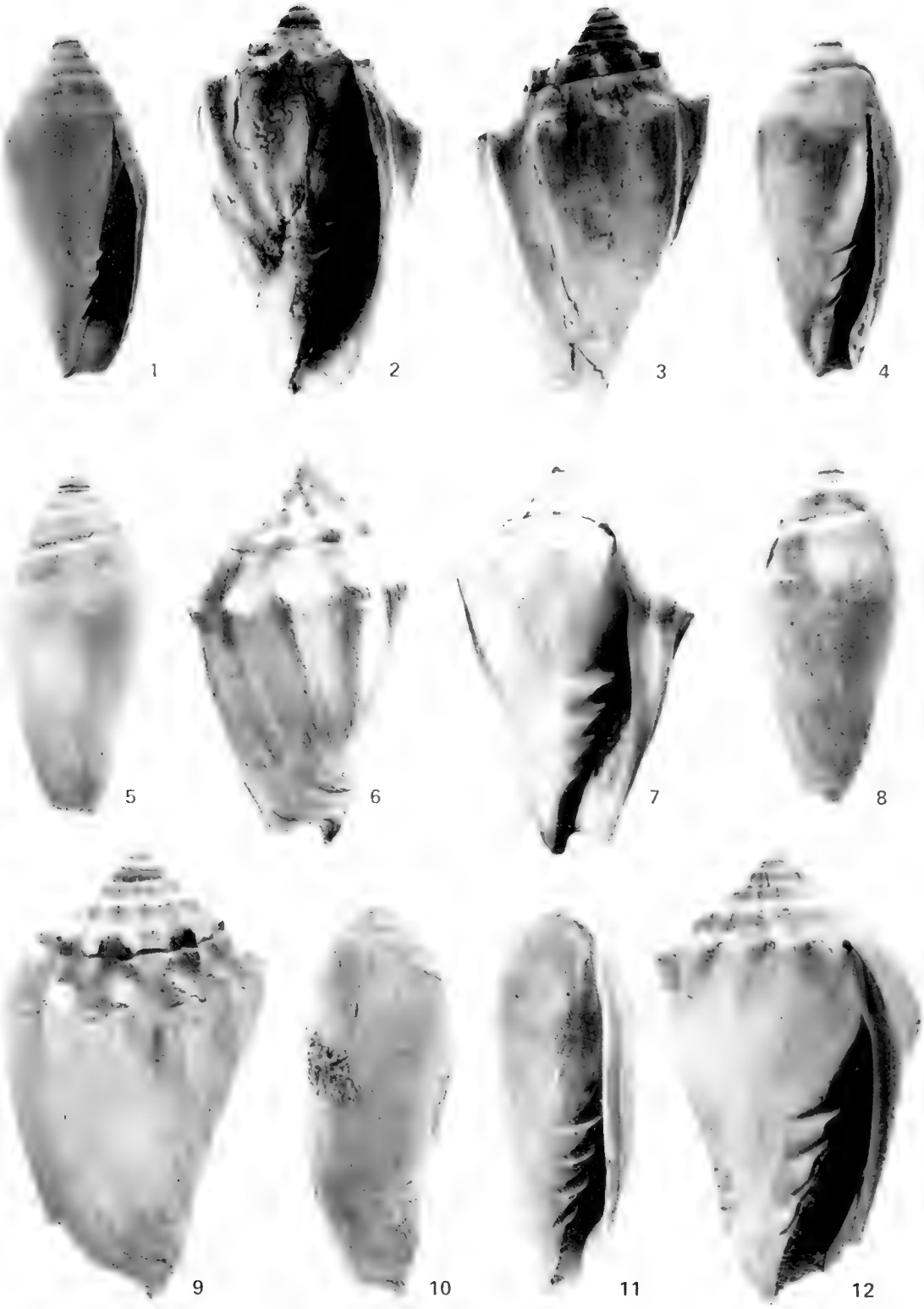
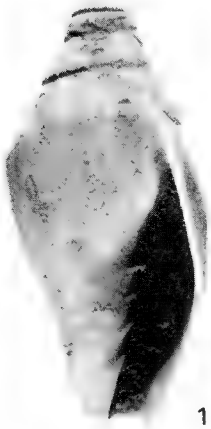
PLATE 9

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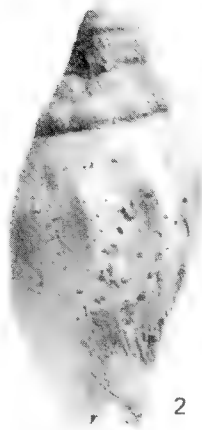
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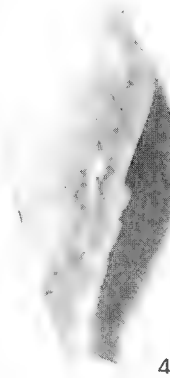
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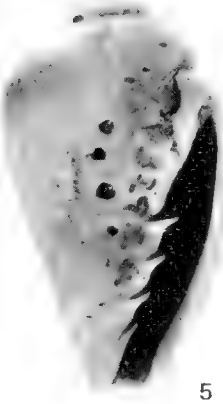
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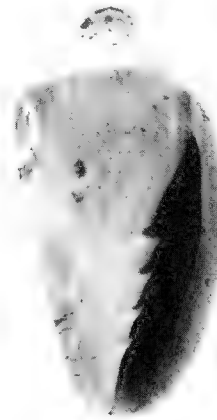
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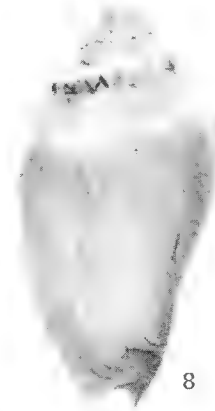
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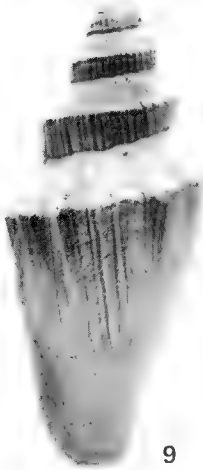
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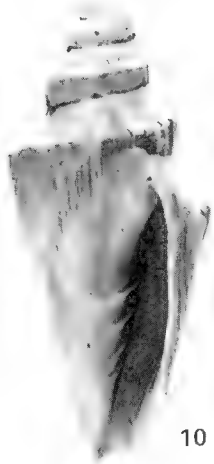
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PLATE 11


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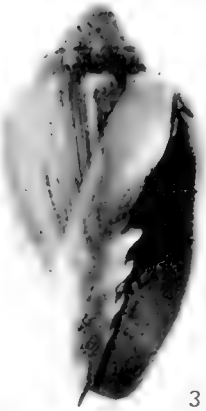
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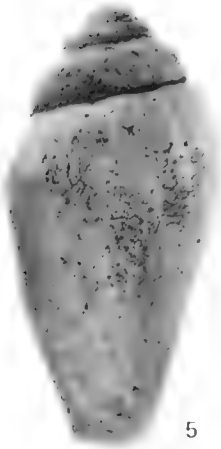
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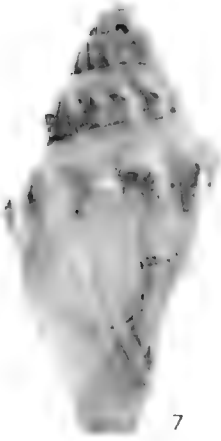
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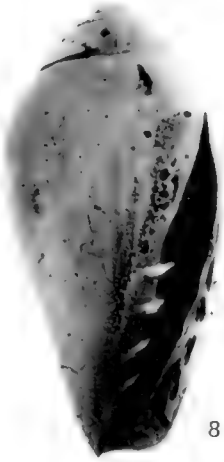
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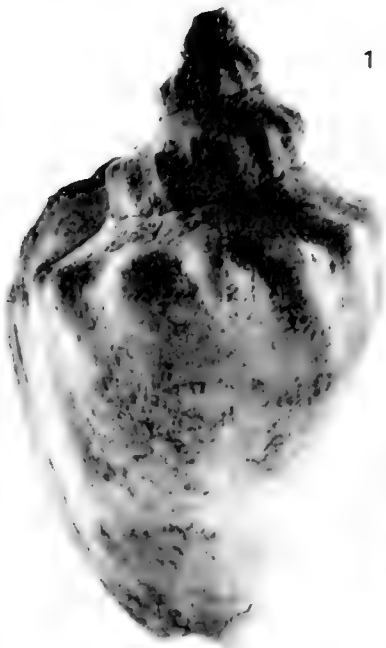
PLATE 19



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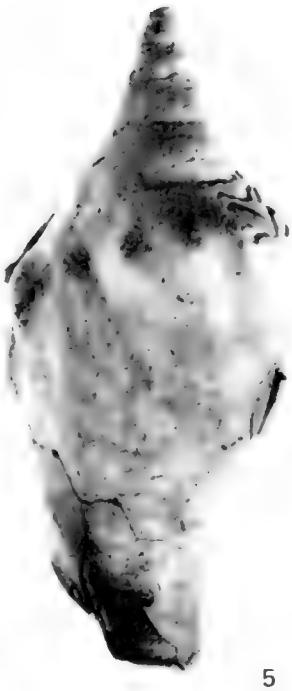

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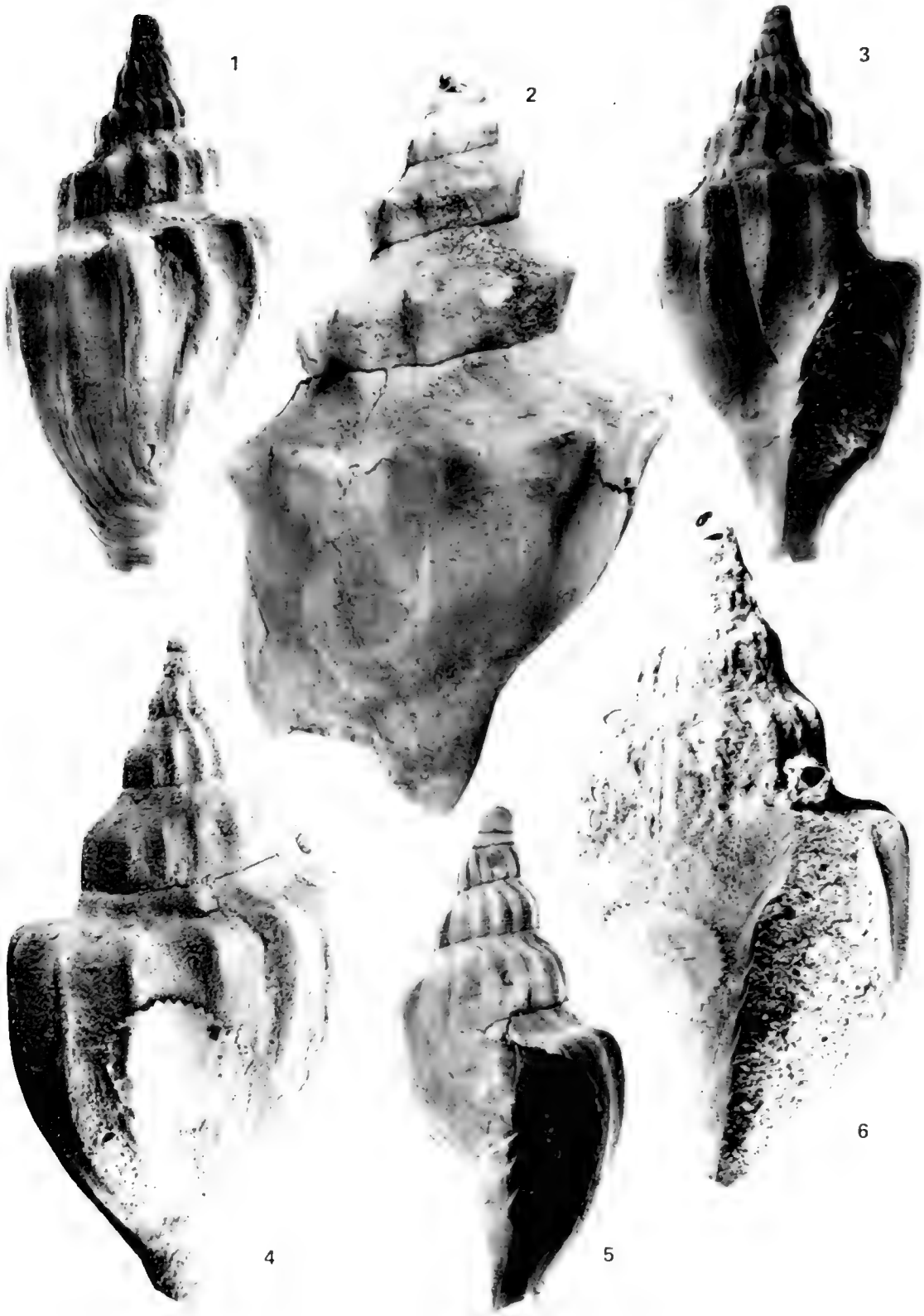
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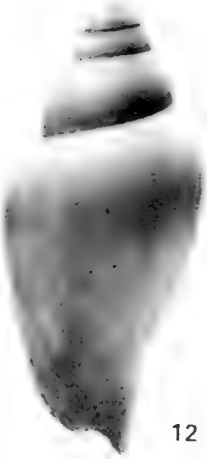

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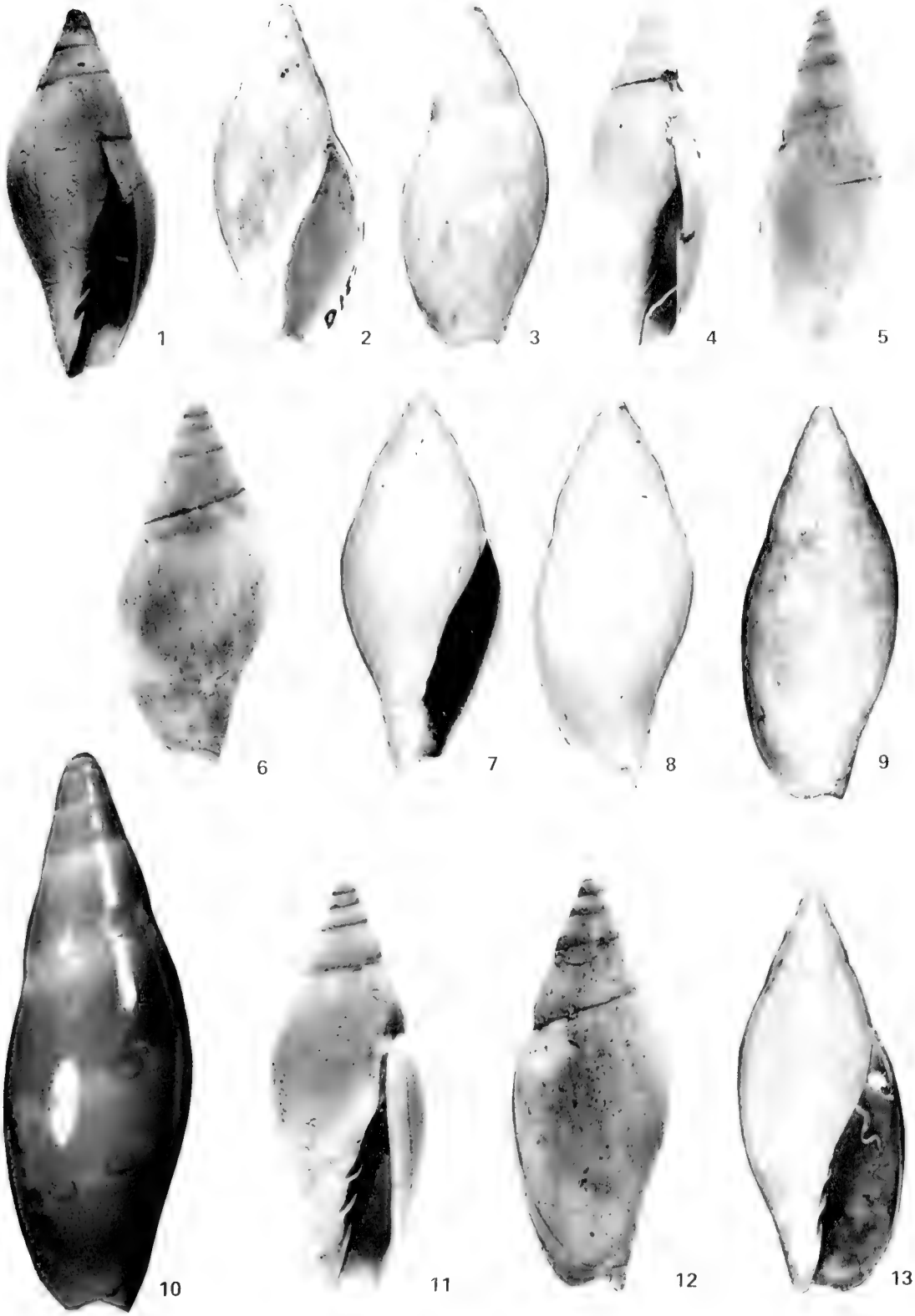
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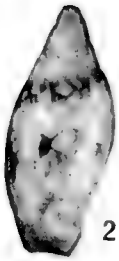
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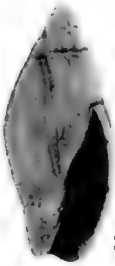
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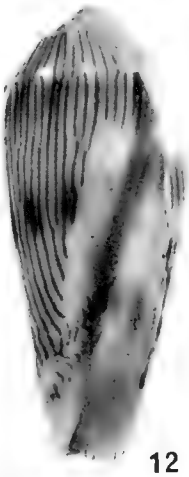
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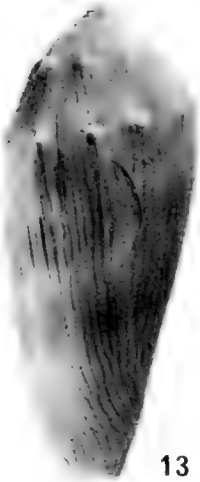
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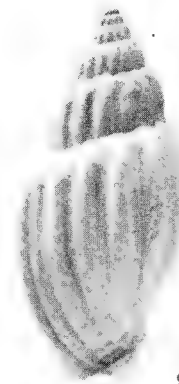
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PSEUDOSCORPIONS FROM THE KRAKATAU ISLANDS AND ADJACENT REGIONS, INDONESIA (CHELICERATA: PSEUDOSCORPIONIDA)

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Abstract

Harvey, M.S. 1988. Pseudoscorpions from the Krakatau Islands and adjacent regions, Indonesia (Chelicerata: Pseudoscorpionida). *Memoirs of the Museum of Victoria* 49: 309–353.

Eighteen pseudoscorpion species are recorded from Krakatau islands and adjacent regions: *Tyrannochthonius krakatau* sp.nov., *T. bagus* sp. nov., *Lagynochthonius kapi* sp. nov., *L. johni* (Redikorzev), *L. thorntoni* sp. nov., *L. hamatus* sp. nov. (Chthoniidae), *Garypus maldivensis* Pocock (Garypidae). *Geogarypus javanus* (Tullgren), *G. albus* Beier (Geogarypidae), *Amblyolpium bellum* Chamberlin, *Beierolpium oceanicum* (With) (Olpiidae), *Metawithius yurii* (Redikorzev) (Withiidae), *Paratemnus assimilis* Beier (Atemnidae), *Haplochernes warburgi* (Tullgren), *H. kraepelini* (Tullgren), *Allochernes liwa* sp. nov., *Verrucachernes oca* Chamberlin, and *Smeringochernes* sp. (Chernetidae). All species except the last are fully described. The following synonymies are proposed: *Geogarypus formosanus* Beier, *G. audyi Beier and G. javanus takensis Beier with G. javanus* (Tullgren); *Xenolpium oceanicum palauense* Beier, *X. oceanicum reductum* Beier and *X. oceanicum latum* Beier with *Beierolpium oceanicum* (With); and *Microchernes orientalis* Beier and *M. insularis* Beier with *Verrucachernes oca* Chamberlin. Their biogeography and ecology are discussed. *Oratemnus proximus* Beier (Atemnidae) is recorded from Java for the first time, based on a specimen included in the type series of *Haplochernes kraepelini*.

Contents

Introduction

The Krakatau Islands lie midway between Java and Sumatra in the Sunda Strait and have attracted considerable attention due to the enormous eruption of 1883 which has been documented by many authors (see Thornton and Rosengren, in press). This eruption eliminated all living matter on the islands, yet within a short space of time, plants and animals had established themselves on the three islands then present, Rakata, Panjang and Sertung; the fourth island, Anak Krakatau, emerged from the sea in 1930 and presently contains the active cone of the volcano.

The first pseudoscorpions to be recorded from the Krakatau Islands were collected by E. Jacobson in May 1908 and identified by Tullgren (1912) as *Chelifer birmanicus* Thorell. As shown below, the material was misidentified and the material actually pertains to *Paratemnus assimilis* Beier. The next collection to be made was by Bristowe (1931) who recorded two species on "Lang Eiland" (Panjang); these specimens have not been available for study. Dammerman (1948) reported the presence of pseudoscorpions on the islands. These specimens were apparently sent to J. C. Chamberlin but have not been available for the present study. Pseudoscorpions were reported from Panjang and Anak Krakatau by Oey et al. (1984) but were not identified any further.

Thus, the 146 specimens collected on the islands by me and others during the 1984 La Trobe Krakatau Expedition, plus further material (28 specimens) collected in the 1985 trip constitute the largest collection to be obtained from the islands. This is not particularly surprising considering the duration and completeness of the La Trobe expeditions (Thornton and Rosengren, in press). In addition, work undertaken at Liwa, Sumatra, and Ujung Kulon and Carita, Java during the 1984 trip yielded a further 86 specimens. All of this material (a total of 260 specimens) is treated in this paper.

Eleven species were collected on the Krakatau islands. All were taken from Rakata, and some were found on the other islands. Seven other species were collected at one or more of the other 1984 study sites, Ujung Kulon, Java, and Liwa, Sumatra.

Materials and methods

Specimens were borrowed from or have been lodged in the following institutions:

ANIC, Australian National Insect Collection, Division of Entomology, Canberra, Australia;

BMNH, British Museum (Natural History), London, England;

BPBM, Bernice P. Bishop Museum, Honolulu, U.S.A.;

FMNH, Field Museum of Natural History, Chicago, U.S.A.;

JCC, J.C. Chamberlin collection, Pacific University, Forest Grove, Oregon, U.S.A.;

MZB, Museum Zoologicum Bogoriense, Bogor, Indonesia;

NHMB, Natural History Museum Basel, Switzerland;

NHMW, Naturhistorisches Museum, Wien, Austria;

NMV, Museum of Victoria, Melbourne, Australia;

RMNH, Rijksmuseum van Natuurlijke Histoire, Leiden, The Netherlands;

SMF, Natur-Museum Senckenberg, Frankfurt-am-Main, Federal Republic of Germany;

USNM, United States National Museum, Washington, D.C., U.S.A.;

UZM, Universitets Kobenhavn, Denmark;

ZIL, Academy of Sciences, Leningrad, U.S.S.R.;

ZMB, Museum fur Naturkunde an der Universitat Humboldt zu Berlin, Democratic Republic of Germany;

ZMH, Zoologisches Museum fur Hamburg, Federal Republic of Germany.

Unless otherwise stated, the type material of described species has been examined.

The litter dwelling specimens were extracted from sieved litter placed in Winkler traps for 2–4 days. Other specimens were collected by searching directly under the bark of decorticating trees, under the bark of rotting logs or under rocks. The study sites have been described by Thornton and Rosengren (in press). All specimens were initially preserved in 70% ethanol and most were mounted on microscope slides in Euparal following the technique of Hoff (1949); specimens preserved in the

former manner are denoted SP, and those in the latter manner are denoted SL. All specimens were given individual numbers (e.g., MH827.01) as explained in Harvey (1985). Measurements were taken in accordance with Harvey (1987), and where they are presented as a fraction, the numerator refers to the length of the structure and the denominator to its width. Terminology generally follows Chamberlin (1931), except for that of the genitalia which follows Legg (1974, 1975) and is summarised below, the cheliceral setae which follows Harvey (1987), and TS which refers to the distance of the tactile seta from the proximal end of the tarsus of leg IV divided by the length of the tarsus. The carapaceal formulae for the chthoniids follows the format of Gabbutt and Vachon (1963).

Genitalic abbreviations

aa, anterior apodeme;
apdg, atrium of posterior dorsal gland;
ca, chitinised arch;
da, dorsal apodeme;
dag, dorsal anterior gland;
dmgs, duct of median genital sac;
ejc, ejaculatory canal;
ejca, ejcaulatory canal atrium;
la, lateral apodeme;
lr, lateral rod;
mgs, median genital sac;
pv, posterior diverticulum of ventral diverticulum;
pvdv, posterior ventral diverticulum;
trmdv, thickened roof of median diverticulum.

Biogeography and ecology

The distribution of each of the species collected during the 1984 and 1985 expeditions is shown in Table 1 and is discussed in more detail below.

1. *Tyrannochthonius krakatau.* This species has so far only been collected in litter on the summit of Rakata and at Ujung Kulon, Java.

2. *Tyrannochthonius bagus.* This species has only been found in litter at Liwa, Sumatra.

3. *Lagynochthonius kapi.* This species is widespread on the Krakatau Islands, but has not yet been located elsewhere. On Rakata it has been collected at Zwarte Hoek and at the summit. It has been taken from rainforest and *Casuarina equisetifolia* J.R. & G. Forst. litter and taken from the underside of rocks on Anak Krakatau.

4. *Lagynochthonius johni.* This species has been recorded from east-central Sumatra and Negros Island, Philippines, and the present record from Ujung Kulon extends its distribution to Java.

5. *Lagynochthonius thorntoni.* This species has been collected only once under the bark of a log on the beach at Ujung Kulon, Java.

6. *Lagynochthonius hamatus.* This species has only been collected in rainforest litter at Liwa, Sumatra.

7. *Garypus maldivensis.* Previously reported from the Maldive Islands and Sri Lanka, this species, like other members of the genus, is a supralittoral form that is probably distributed along the shoreline in drifting plant material as described by Lee (1979) for *G. californicus* Banks. *Garypus maldivensis* was found only once on the islands at Zwarte Hoek under the bark of a dead *Barringtonia asiatica* (L.) Kurz on the beach.

8. *Geogarypus javanus.* This species is widely distributed in southeast Asia (Thailand, Malaysia, Taiwan, Papua New Guinea, Indonesia, Solomon Islands, and various island groups in Micronesia). It is most commonly found in litter, but has been taken by beating vegetation on Krakatau and Ujung Kulon, Java.

9. *Geogarypus albus.* The only previous collection is that of the the type material collected from Malaysia. All of this material was taken from birds' nests, but the specimen collected from Ujung Kulon was taken from litter.

10. *Amblyolpium bellum.* Until now, the only known collection sites of this species were Kepulauan Banda, Maluku and Tjibodas, Java. On Krakatau, it has been collected from Rakata and Panjang, under the bark of trees including *Ficus* sp. and *Timonius compressicaulis* (Miq.) Boerl.

11. *Beierolpium oceanicum.* This is a widespread species and has been collected from Krakatau to Samoa.

12. *Metawithius yurii.* This species has previously been collected only at the type localities in Cambodia (Kampuchea) and Vietnam. On the Krakataus, it has only been collected from Rakata and Sertung. All specimens except one from Sertung, which was collected under bark of a dead *Ficus* sp. on the beach, were taken by beating vegetation in rainforest.

13. *Paratemnus assimilis.* This species was originally described from the Philippines and was collected by the La Trobe expeditions near Carita, Java from under the bark of a dead tree in secondary rainforest, and on Rakata by beating vegetation, in litter and from the inside of a tent.

Table 1. Collection sites of each of the species collected during the 1984 and 1985 expeditions (abbreviations: L, Liwa; R, Rakata; A, Anak Krakatau; P, Panjang; S, Sertung; C, Carita; U, Ujung Kulon).

	L	R	A	P	S	C	U
Chthoniidae							
Tyrannochthonius krakatau sp. nov.		x					x
Tyrannochthonius bagus sp. nov.	x						
Lagynochthonius kapi sp. nov.		x	x	x	x		
Lagynochthonius johni (Redikorzev)							x
Lagynochthonius thorntoni sp. nov.							x
Lagynochthonius hamatus sp. nov.	x						
Garypidae							
Garypus maldivensis Pocock		x					
Geogarypidae							
Geogarypus javanus (Tullgren)		x					x
Geogarypus albus Beier							x
Olpiidae							
*Amblyolpium bellum*Chamberlin		x		x			
Beierolpium oceanicum (With)		x	x		x		
Withiidae							
Metawithius yurii (Redikorzev)		x			x		
Atemnidae							
Paratemnus assimilis Beier		x				x	
Chernetidae							
Haplochernes warburgi (Tullgren)		x			x		
Haplochernes kraepelini (Tullgren)		x				x	
Allochernes liwa sp. nov.	x						
Verrucachernes oca Chamberlin		x		x	x		
Smeringochernes sp.							x

14. *Haplochernes warburgi.* This species was originally described from Java, but has since been reported from Sulawesi, Papua New Guinea and Sri Lanka. It is one of the most common pseudoscorpion species on Krakatau and has so far been collected on all of the islands except Anak Krakatau. It was most commonly collected by beating or sweeping vegetation, and was often found within the campsite. It was observed moving around inside tents and on structures during the day and appears to be at least partially diurnal. There is every likelihood that this species may be moved from island to island by human activity.

15. *Haplochernes kraepelini.* This species has been collected in Java and the Palau and Caroline Islands in Micronesia. The material collected by the La Trobe expeditions was taken under bark of trees (Carita, Java) or by beating (Rakata). It was not found on any of the Krakatau islands except Rakata.

16. *Allochernes liwa.* This species has only been taken at Liwa, Sumatra by beating vegetation.

17. *Verrucachernes oca.* This species is very widely distributed in south-east Asia from Vietnam to the Solomon Islands. It was collected on all of the Krakatau islands except Anak Krakatau, under the bark of logs or dead trees.

Bush and Whittaker (1986) divided the flora of the islands into three main types, two of which were further divided. The "coastal zone" includes the "*Casuarina* communities", "*Barringtonia* communities" and the "*Pes-caprae* formation". The "lowland forest" includes six forest types, each characterised by a different tree species or group of species. The "montane forest", found only on the summit of Rakata, is rich in *Schefflera poly-*

botrya (Miq.) Vig. The eleven pseudoscorpion species collected on the Krakataus may be readily classified with reference to these three groups (Table 2). Further classification into the six lowland groups is not possible due to the combined effect of the lack of suitable data collected on the tree formations during the collection of the animals, and the apparent widespread distribution of most of the pseudoscorpions in the lowland formations. A further zone is recognised in the "coastal zone" for the purposes of this discussion, the "littoral zone".

(1) Coastal zone. The littoral zone contained two pseudoscorpion species, *Garypus maldivensis* and *Beierolpium oceanicum,* both of which were collected under the bark of dead trees on the beach at Rakata. Two other species, *Verrucachernes oca* and *Metawithius yurii,* were collected from under the bark of a dead *Ficus* sp. overhanging the beach at Sertung, but I have my doubts that the branch was truly affected by waves. The tree was in an area where the lowland forest came right down to the beach, and these two species may simply be incursive elements in the coastal zone.

Lagynochthonius kapi and *B. oceanicum* were commonly found in the *Casuarina equisetifolia* litter, while *Geogarypus javanus* and *Haplochernes warburgi* were found on the spit at Sertung.

(2) Lowland zone. The lowland pseudoscorpion fauna was the most diverse, which is consistent with the floral analysis of Bush and Whittaker (1986). *Amblyolpium bellum* and *V. oca* were commonly found under the bark of living trees and logs, while *L. kapi* and *B. oceanicum* were present in the litter, along with *Paratemnus assimilis* which was collected once from litter on Rakata. *Geogarypus javanus, H. warburgi, M. yurii* and *P. assimilis* were taken by beating and sweeping vegetation.

(3) Montane zone. Only two pseudoscorpion species were collected in the montane zone, *L. kapi* and *Tyrannochthonius krakatau.* The latter is restricted to this zone.

In general, the pseudoscorpion fauna of the Krakataus is fairly well developed, especially considering that the fauna and flora of the islands was totally destroyed in the 1883 eruption (Thornton and Rosengren, in press). How then did they reach the islands, presumably from either Java, Sumatra or both? The three options are (1) phoresy, (2) rafting, or (3) by human introduction.

(1) Pseudoscorpions have long been known to attach themselves to larger animals, especially insects, and thus obtain transport. While none of the pseudoscorpions collected on these expeditions were undertaking phoresy, populations of many of the species may have become established after transportation on an aerial host.

Table 2. Occurrence of pseudoscorpion species on the Krakatau islands in relation to floral communities (Bush and Whittaker 1986) and collecting method.

	coastal		lowland	montane
	littoral	*Casuarina*		
litter		*L. kapi* *B. oceanicum*	*L. kapi* *B. oceanicum* *P. assimilis*	*L. kapi* *T. krakatau*
bark	*G. maldivensis* *B. oceanicum* (*M. yurii*) (*V. oca*)		*A. bellum* *V. oca* (*M. yurii*)	
other		*G. javanus* *H. warburgi*	*G. javanus* *H. warburgi* *H. kraepelini* *M. yurii* *P. assimilis*	

(2) Banks of floating vegetation or logs may provide transport for some species, but submersion in sea water may kill many species. The specimens of *Garypus maldivensis* collected from under the bark of a dead tree on the shore of Rakata most probably dispersed to the island by rafting.

(3) While I have no solid evidence to suggest that pseudoscorpions have been transported to the islands through human agency, it is a possibility that cannot be easily discounted. There have been many visitors to the islands over the years, and introductions may have occurred, especially in items such as food (e.g. bananas, coconuts, etc.), or on pieces of timber or branches and logs. This is especially likely for species such as *Haplochernes warburgi* which is at least partially diurnal (see above).

Systematics

Chthoniidae

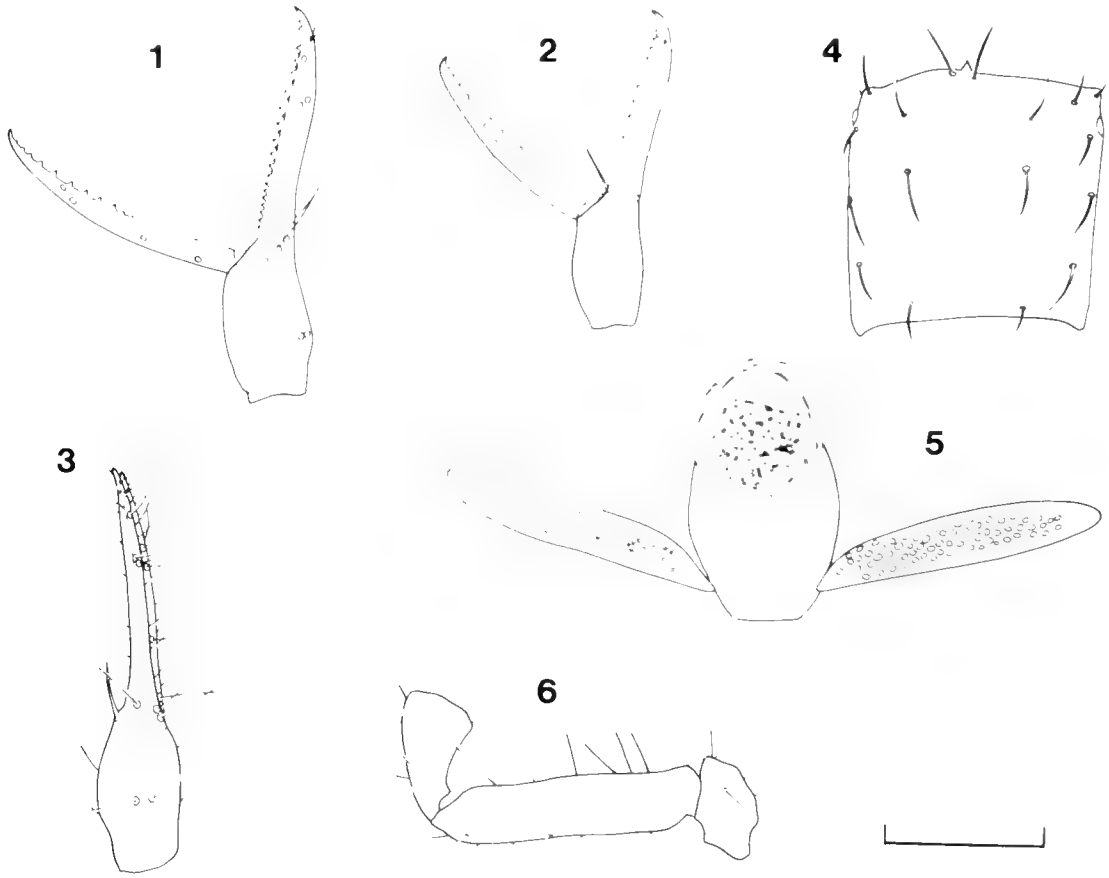
Tyrannochthonius Chamberlin

Tyrannochthonius krakatau sp. nov.

Figures 1–6

Type material. Holotype ♀, Rakata, summit, Krakatau Islands, 6°09'S, 105°26'E, 813 m, 19 Sep 1984, litter (MZB, 48-B, MH842.01, SL).

Paratypes: 3 ♀, same data as holotype (MZB, 48-B, MH842.02-04, SL); 5 ♀, same data as holotype (1 ♀ in ANIC, remainder in NMV, K714-717, 40-29, MH844.01-05, SL and SP); 1 ♀, 1 tritonymph, Pulau Peucang, Ujung Kulon, Java, 6°45'S, 105°15'E, 19 Sep 1984, litter



Figures 1–6. *Tyrannochthonius krakatau* sp. nov. Figs 1, 4, 5, holotype female. Figs 3, 6, paratype female, MH844.04. Fig. 2, paratype tritonymph, MH816.02. Fig. 1, left chela, lateral. Fig. 2, left chela, lateral. Fig. 3, right chela, dorsal. Fig. 4, carapace. Fig. 5, genitalia, ventral. Fig. 6, right pedipalp, ventral. Scale line = 0.17 mm (figs 1–4, 6), 0.06 mm (fig. 5).

(MZB, 119-AN, MH816.01-02, SL).

Diagnosis. The only other described Asian or Australasian species of *Tyrannochthonius* that possess only two eyes are *T. laevis* Beier, *T. similidentatus* Sato and *T. bagus* sp. nov. *Tyrannochthonius krakatau* differs from *T. laevis* by its more prominent chelal teeth, from *T. similidentatus* by its heterodentate fixed chelal finger, and from *T. bagus* by the small intercalary teeth on the moveable chelal finger and by the form of the female genitalia.

Description. Female only. Colour pale yellow-brown, pedipalps and carapace slightly darker. Setae acuminate. Pleural membrane papillo-striate. Pedipalp (Figs 3, 6): trochanter 1.35–1.69, femur 4.13–4.36, tibia 1.72–1.83, chela 4.85–5.05, hand 1.50–1.73 times as long as broad. Fixed chelal finger and hand with 8 trichobothria, moveable chelal finger with 4 trichobothria; *ib* and *isb* on dorsum of hand (Fig. 1). Hand with 1 stout, medial, lanceolate, spine-like seta at level of *ist*. Venom apparatus absent. Chelal teeth: fixed finger with 19–20 large, well-spaced, erect teeth, plus 10 small intercalary teeth between anterior teeth; moveable finger with 9 well-spaced, erect teeth, plus 8 small intercalary teeth between anterior teeth, and 9–10 low, rounded basal teeth. Moveable finger twice as long as hand; moveable finger with very small basal apodeme. Chelicera with 5 setae on hand, all acuminate; flagellum of 6 blades; moveable finger with 1 seta; galea a very low elevation. Carapace (Fig. 4) 0.95–1.05 times as long as broad; 2 small corneate eyes; epistome acutely triangular, with 2 closely appressed setae; with m4m: 4: 4: 2: 2 setae. Tergites and sternites undivided. Tergal chaetotaxy: 4: 4: 4: 4: 4: 4: 4: 4: 4: 4: 4: 0. Sternal chaetotaxy: 9–10: (3)8–9(3): (3)6–10(3): 8–10: 9–10: 8: 8–9: 8–9: 7–9: 0: 2. Coxal chaetotaxy: 3: 4cs: 5: 5; coxae II with 6–8 distally incised coxal spines set in oblique row; intercoxal tubercle absent. Genital opercula not unusual. Female genitalia as in Fig. 5. Spiracles with stigmatic helix. Legs: heterotarsate, arolium slightly shorter than claws; claws simple.

Dimensions (mm): body length 0.85–0.93; pedipalps: trochanter 0.115–0.135/ 0.08–0.085, femur 0.305–0.335/0.07–0.08, tibia 0.155–0.165/ 0.085–0.09, chela 0.46–0.49/0.095–0.10, hand length 0.155–0.165, moveable finger length 0.305–0.33; chelicera 0.26–0.275/0.135–0.155, moveable finger length 0.14–0.155; carapace 0.28–0.295/0.28–0.30, eye 0.025; leg I: trochanter 0.075–0.09/ 0.055–0.065, basifemur 0.17–0.18/ 0.045–0.05, telofemur 0.09–0.095/ 0.04–0.045, tibia 0.07–0.105/0.03–0.035, tarsus 0.175–0.19/ 0.03; leg IV: trochanter 0.11/0.075–0.08, basifemur 0.125–0.145/0.12–0.125, telofemur 0.185–0.20/ 0.11–0.125, tibia 0.185–0.195/0.05–0.055, basitarsus 0.085–0.115/0.03–0.045, telotarsus 0.175–0.18/ 0.03.

Tritonymph: colour pale. Pedipalp: trochanter 1.62, femur 3.69, tibia ?, chela 4.23, hand 1.35 times as long as broad. Fixed chelal finger and hand with 7 trichobothria, moveable finger with 3 trichobothria; *isb* and *sb* absent (Fig. 2). Carapace with m4m: 4: 4: 2: 2 setae; 1.15 times as long as broad. Tergal chaetotaxy: 4: 4: 4: 4: 4: 4: 4: 4: 4: 4: 4: 0. Sternal chaetotaxy: 5: (2)4(2): (2)5(2): 6: 6: 6: 6: 6: 7: 0: 2. Coxal chaetotaxy: 3: 3cs: 4: 4; coxae II with 5–6 distally incised spines set in oblique row. Heterotarsate.

Dimensions (mm): body length 0.64; pedipalps: trochanter 0.105/0.065, femur 0.24/0.065, tibia ?, chela 0.36/0.085, hand length 0.115, moveable finger length 0.245; carapace 0.235/0.205.

Etymology. The specific epithet refers to the group of islands on which this species has been found and is to be treated as a noun in apposition.

Remarks. This species has been collected in litter only on the summit of Rakata and at Pulau Peucang.

Tyrannochthonius bagus sp. nov.

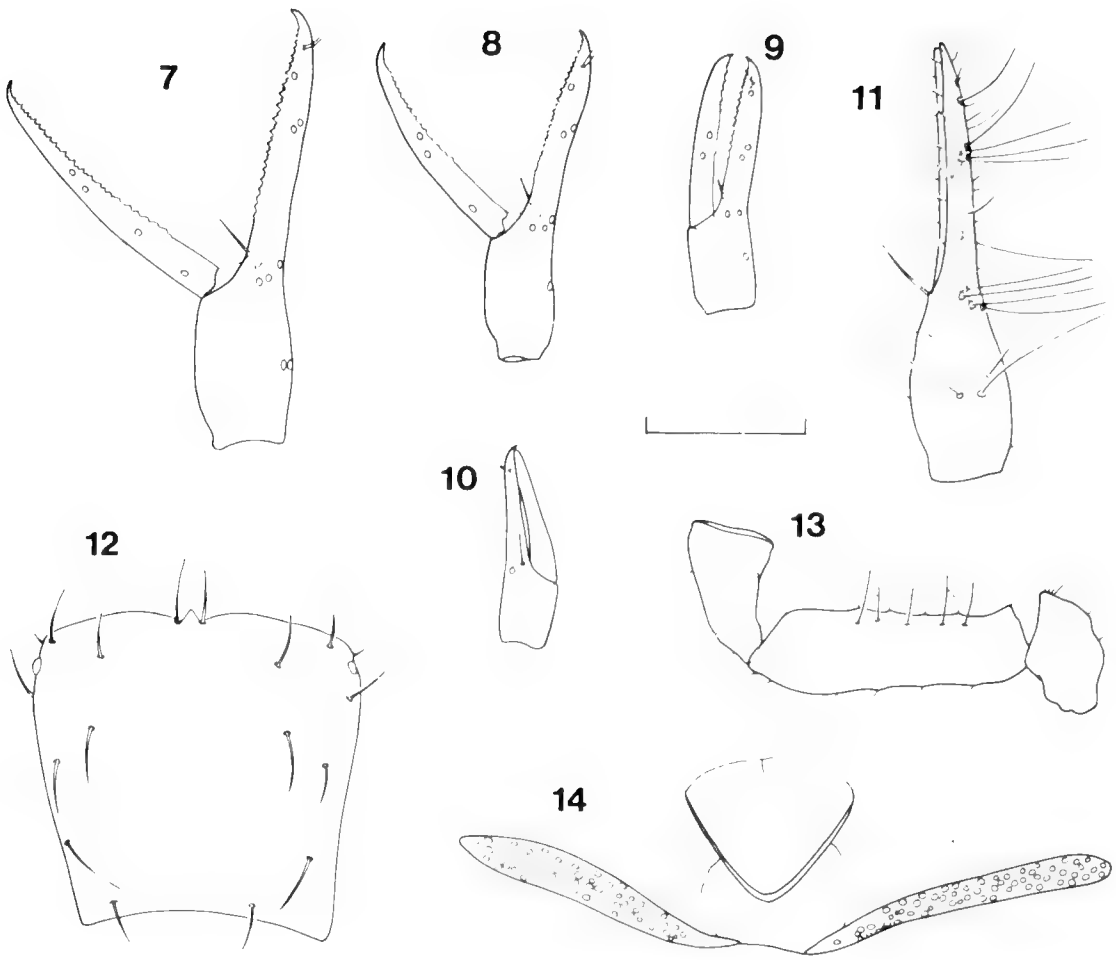
Figures 7–14

Type material. Holotype ♀, 7.5 km W of Liwa, Sumatra, 5°04'S, 104°03'E, 730 m, litter, 1 Sep 1984 (MZB, 91-M, MH807.01, SL).

Paratypes: 9 ♀, 2 tritonymphs, 1 protonymph, same data as holotype (MZB, 91-M, MH807.02-13, SL and SP); 15 ♀, 2 tritonymphs, 1 deutonymph, same data as holotype except 6 Sep 1984 (2 ♀, 1 deutonymph in MZB, 2 ♀ in ANIC, remainder in NMV, K718-730, 148-Q, MH809.01-18, SL and SP); 9 ♀, 6 km W of Liwa, Sumatra, 5°04'S, 104°03'E, 640 m, litter, 5 Sep 1984 (MZB, 150-M, MH808.01-09, SP).

Diagnosis. As discussed under the diagnosis of *T. krakatau, T. bagus* resembles *T. laevis, T. similidentatus* and *T. krakatau* in possessing only two eyes. *Tyrannochthonius bagus* differs from *T. laevis* in its erect chelal teeth, from *T. similidentatus* in its heterodentate chelal teeth, and from *T. krakatau* in the large intercalary teeth of the moveable chelal finger and the form of the female genitalia.

Description. Female only. Colour pale yellow-brown, pedipalps and carapace slightly darker. Setae acuminate. Pleural membrane papillo-striate.



Figures 7–14. *Tyrannochthonius bagus* sp. nov. Figs 7, 11, 13, 14, holotype female. Fig. 8, paratype tritonymph, MH809.16. Fig. 9, paratype deutonymph, MH809.18. Fig. 10, paratype protonymph, MH807.13. Fig. 12, paratype female, MH809.01. Fig. 7, left chela, lateral. Fig. 8, left chela, lateral. Fig. 9, left chela, lateral. Fig. 10, left chela, lateral. Fig. 11, right chela, dorsal. Fig. 12, carapace. Fig. 13, left pedipalp, dorsal. Fig. 14, genitalia, ventral. Scale line – 0.17 mm (figs 7–13), 0.06 mm (fig. 14).

Pedipalp (Figs 11, 13): trochanter 1.58–1.71, femur 3.37–3.83, tibia 1.80–1.90, chela 4.35–4.71, hand 1.48–1.57 times as long as broad. Fixed chelal finger and hand with 8 trichobothria, moveable chelal finger with 4 trichobothria; *ib* and *isb* on dorsum of hand (Fig. 7). Hand with 1 stout medial spine-like seta at level of *ist*. Venom apparatus absent. Chelal teeth: fixed finger with 22–23 large, well-spaced, retrorse teeth, plus 16–18 large intercalary teeth; moveable finger with 20–25 well-spaced, retrorse teeth, plus 11–14 large intercalary teeth. Moveable finger twice as long as hand; moveable finger with very small basal apodeme. Chelicera with 5 setae on hand, all acuminate; flagellum of 7 blades; moveable finger with 1 seta; galea a very low elevation. Carapace (Fig. 12) 0.90–1.00 times as long as broad; 2 small corneate eyes; epistome acutely triangular, with 2 closely appressed setae; with m4m: 4: 4: 2: 2 setae. Tergites and sternites undivided. Tergal chaetotaxy: 4: 4: 4: 4: 4: 4: 4: 4: 4: 4: 4: 0. Sternal chaetotaxy: 10: (2)10(2): (2)10(2): 10: 9–10: 9: 9: 9–10: 9–10: 0: 2. Coxal chaetotaxy: 3–4: 2–4cs: 5: 5; coxae II with 5–7 distally incised coxal spines set in oblique row; intercoxal tubercle absent. Genital opercula not unusual. Female genitalia (Fig. 14) with long, narrow lateral diverticulum. Spiracles with stigmatic helix. Legs: heterotarsate, arolium slightly shorter than claws; claws simple.

Dimensions (mm): body length 0.91–1.05;

pedipalps: trochanter 0.145–0.155/0.085–0.095, femur 0.32–0.345/0.09–0.095, tibia 0.18–0.185/ 0.095–0.10, chela 0.48–0.50/0.105–0.115, hand length 0.165–0.18, moveable finger length 0.32–0.35; chelicera 0.29–0.30/ 0.15–0.18, moveable finger length 0.165–0.175; carapace 0.325–0.345/0.345–0.37; leg I: trochanter 0.09–0.095/0.07–0.075, basifemur 0.185–0.195/ 0.06, telofemur 0.10–0.105/0.06, tibia 0.105–0.11/0.04–0.045, tarsus 0.17–0.185/ 0.03–0.035; leg IV: trochanter 0.115–0.12/ 0.08–0.09, basifemur 0.19–0.195/ 0.14–0.145, telofemur 0.205–0.215/0.13–0.135, tibia 0.20–0.21/0.06–0.065, basitarsus 0.09–0.095/ 0.045–0.05, telotarsus 0.175–0.18/0.035–0.04.

Tritonymph: colour pale. Pedipalp: trochanter 1.60–1.64, femur 3.29–3.46, tibia 1.71, chela 4.06–4.12, hand 1.35–1.44 times as long as broad. Fixed chelal finger and hand with 7 trichobothria, moveable finger with 3 trichobothria; *isb* and *sb* absent (Fig. 8). Carapace with m4m: 4: 4: 2: 2 setae. Tergal chaetotaxy: 4: 4: 4: 4: 4: 4: 4: 4: 4: 4: 4: 4: 0. Sternal chaetotaxy: 5: (2)4(2): (2)6(2): 7–8: 6–8: 7: 7: 7: 6–7: 0: 2. Coxal chaetotaxy: 3: 3–4cs: 4: 4; coxae II with 5 distally incised spines set in oblique row. Heterotarsate.

Dimensions (mm): body length 0.72–0.75; pedipalps: trochanter 0.115–0.12/0.07–0.075, femur 0.225–0.23/0.065–0.07, tibia 0.12/0.07, chela 0.35–0.365/0.085–0.09, hand length 0.115–0.13, moveable finger length 0.24–0.25; carapace 0.27/?.

Deutonymph: colour pale. Pedipalp: trochanter 1.80, femur 3.50, tibia 1.79, chela 3.21, hand 1.43 times as long as broad. Fixed chelal finger and hand with six trichobothria, moveable finger with two trichobothria; *esb*, *isb*, *sb* and *b* absent (Fig. 9). Carapace with m4m: 4: 4: 2: 2 setae; 0.98 times as long as broad. Tergal chaetotaxy: 4: 4: 4: 4: 4: 4: 4: 4: 4: 4: 4: 4: 0. Sternal chaetotaxy: 2: (0)4(0): (0)4(0): 6: 6: 6: 6: 6: 6: 0: 2. Coxal chaetotaxy: 2: 3cs: 3: 3; coxae II with three distally incised spines set in oblique row. Heterotarsate.

Dimensions (mm): body length 0.60; pedipalps: trochanter 0.09/0.05, femur 0.175/0.05, tibia 0.125/0.07, chela 0.225/0.07, hand length 0.10, moveable finger length 0.19; carapace 0.22/0.225.

Protonymph: colour pale. Pedipalp: trochanter 1.60, femur 3.22, tibia ?, chela 3.69, hand 1.15 times as long as broad. Fixed chelal finger with 3 trichobothria, moveable finger with 1 trichobothrium; *eb*, *et*, *ist* and *t* present (Fig. 10). Carapace with 4: 4: 4: 2: 2 setae; 0.84 times as long as broad. Tergal chaetotaxy: 2: 2: 2: 2: 4: 4: 4: 4: 4: 2: 4: 0. Sternal chaetotaxy: 2: (0)0(0): (0)2(0): 2: 4: 4: 4: 4: 4: 0: 2. Coxal chaetotaxy: 1: 1cs: 1: 1; coxae II with 2 distally incised spines set in oblique row. Heterotarsate.

Dimensions (mm): body length 0.45; pedipalps: trochanter 0.08/0.05, femur 0.145/0.045, tibia ?, chela 0.24/0.065, hand length 0.075, moveable finger length 0.16; carapace 0.205/0.245.

Etymology. The specific epithet is Bahasa Indonesie meaning "good" and is to be treated as an indeclinable noun.

Remarks. This is only the second record of a true member of the genus *Tyrannochthonius* from Sumatra. The first is that of *T. terribilis* (With) by Beier (1930) from Padang. Examination of the syntypes of *T. terribilis* (lodged in UZM) revealed that it possesses homodentate chelal fingers, unlike *T. bagus* which possesses heterodentate fingers.

Lagynochthonius Beier

Lagynochthonius kapi sp. nov.

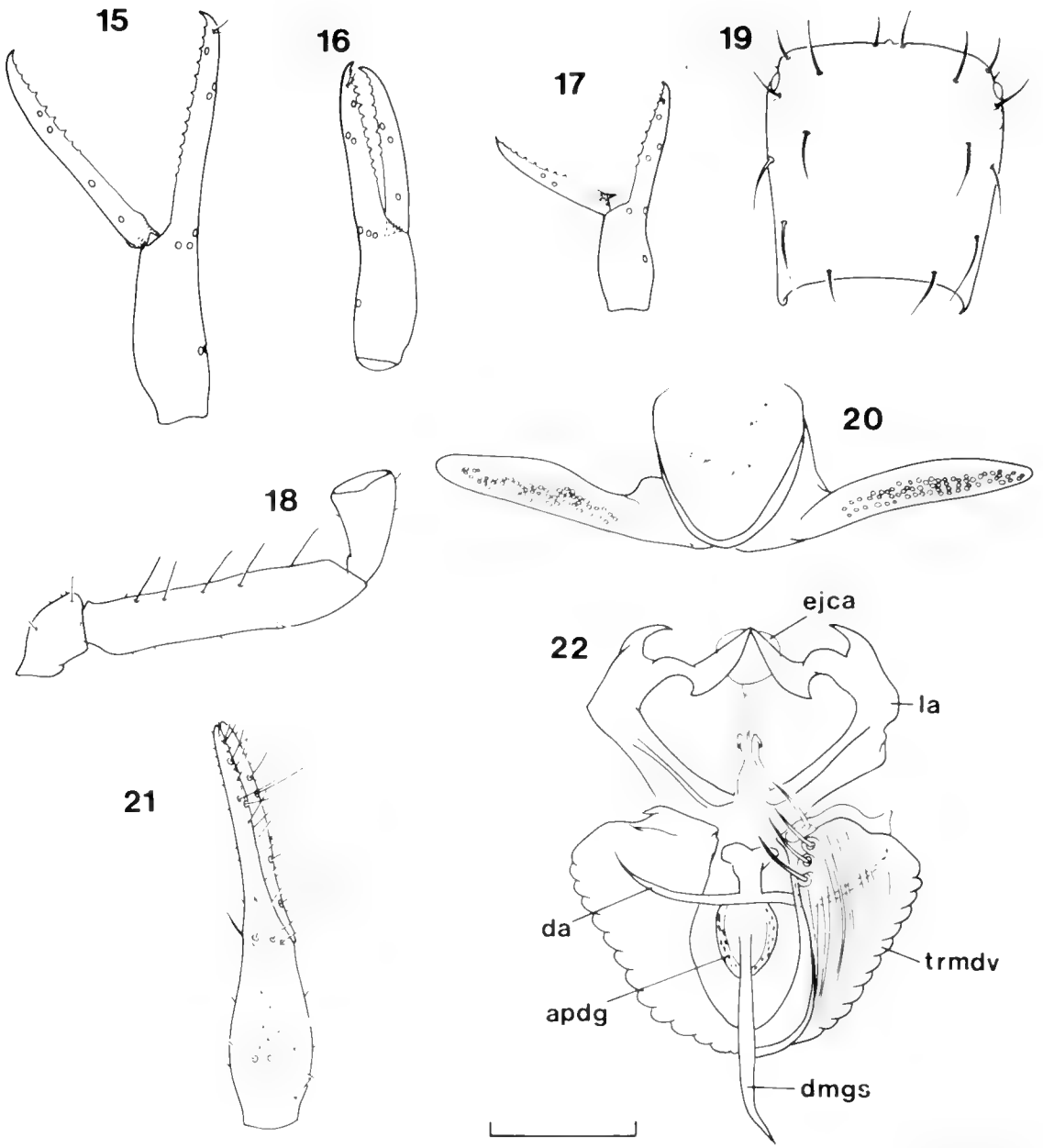
Figures 15–22

Type material. Holotype ♂, Zwarte Hoek, Rakata, Krakatau Islands, 6°09′S, 105°25′E, litter, 12 Sep 1984 (MZB, 156-R, MH820.01, SL).

Paratypes: 5 ♀, same data as holotype (MZB, 156-R, MH820.02-06, SL); 1 ♀, Rakata, summit, Krakatau Islands, 6°09′S, 105°26′E, 813 m, litter, 19 Sep 1984 (MZB, 40-29, MH844.06, SL); 2 ♂, Rakata, summit, Krakatau Islands, 6°09′S, 105°26′E, 813 m, litter, 19 Sep 1984 (MZB, 46-8, MH843.01-02, SL); 3 ♂, 5 ♀, 1 tritonymph, Panjang, Krakatau Islands, 6°05′S, 105°28′E, rainforest litter, 14 Sep 1984 (NMV, K731-739, 154-P, MH861.01-09, SL and SP); 2 ♂, 2 ♀, 1 tritonymph, Sertung, Krakatau Islands, 6°04′S, 105°24′–25′E, *Casuarina equisetifolia* litter, 11 Sep 1984 (MZB, 151-D, MH851.01-05, SP); 4 ♂, 3 ♀, 1 tritonymph, 2 deutonymphs, Anak Krakatau, Krakatau Islands, 6°06′S, 105°26′E, *Casuarina equisetifolia* litter, 10 Sep 1984 (1 ♂, 1 ♀, 1 deutonymph in NMV, K740-742, 1 ♂, 1 ♀ in ANIC, remainder in MZB, 152-I, MH869.01-10, SL); 3 ♂, 1 ♀, Anak Krakatau, Krakatau Islands, 6°06′S, 105°26′E, under rock, 10 Sep 1984 (MZB, 109-E, MH871.01-04, SP).

Diagnosis. This species is approached in its small size only by *L. bakeri* (Chamberlin), *L. brincki* (Beier), and *L. dybasi* (Beier). The latter possesses very slender chelae and the teeth of *L. brincki* are more widely spaced, extending on the moveable finger well past the level of *sb*. It is most similar to *L. bakeri*, from which it differs by possession of intercalary teeth on the moveable chelal finger.

Description. Adults: Pale yellow-brown, pedipalps and carapace slightly darker. Setae acuminate. Pleural membrane papillo-striate. Pedipalp (Figs 21, 18): trochanter 1.64–1.79 (♂), 1.64–1.80 (♀),



Figures 15–22. *Lagynochthonius kapi* sp. nov. Figs 15, 19, 22, holotype male. Fig. 16, paratype tritonymph, MH869.08. Fig. 17, paratype deutonymph, MH869.09. Fig. 18, paratype female, MH861.04. Fig. 20, paratype female, MH861.05. Fig. 21, paratype female, MH861.04. Fig. 15, left chela, lateral. Fig. 16, right chela, lateral. Fig. 17, left chela, lateral. Fig. 18, right pedipalp, dorsal. Fig. 19, carapace. Fig. 20, genitalia, ventral. Fig. 21, right chela, dorsal. Fig. 22, genitalia, ventral, detail of trmdv not shown in right half. Scale line = 0.17 mm (figs 15–19, 21), 0.06 mm (figs 20, 22).

femur 4.53–4.93 (♂), 4.35–5.00 (♀), tibia 1.93–2.21 (♂), 1.82–1.88 (♀), chela 5.33–5.61 (♂), 5.00–5.10 (♀), hand 2.28–2.39 (♂), 2.09–2.25 (♀) times as long as broad. Fixed chelal finger and hand with 8 trichobothria, moveable chelal finger with 4 trichobothria (Fig. 15); *ib* and *isb* on dorsum of hand, *st* close to *t*. Hand with 1 medial acuminate spine-like seta at level of *ist*. Venom apparatus absent. Chelal teeth: fixed finger with 11–15 (♂), 15–16 (♀) large, well-spaced, slightly retrorse teeth,

plus several very small intercalary teeth between anterior teeth; moveable finger with 7–9 (♂) 7–8 (♀) well-spaced teeth in anterior half, plus 2–5 (♂), 1–3 (♀) small intercalary teeth between anterior teeth, remaining teeth low and rounded; terminal tooth of moveable finger not appearing hooked. Fixed finger of male with distal sensorium near *ds*. Moveable finger longer than hand; hand slightly constricted distally; moveable chelal finger with large basal apodeme. Chelicera with 5 setae on hand, all acuminate; flagellum of 8 blades; moveable finger with 1 seta; galeal region a very low elevation. Carapace (Fig. 19) 0.90–1.00 (♂), 0.85–0.97 (♀) times as long as broad; 4 eyes, anterior eye corneate, posterior pair represented by eye spots; epistome very low, with 2 closely appressed setae; with m4m: 4: 4: 2: 2 setae. Tergites and sternites undivided. Tergal chaetotaxy: ♂, 4: 4: 4: 4–6: 5–6: 5–6: 5–6: 6: 5–6: 3–4: 4: 0; ♀, 4: 4: 4: 6–7: 6–7: 7: 6: 6–7: 5–6: 4: 4: 0. Sternal chaetotaxy: ♂, 10: (3)24–28 [8] (3): (3)7–9(3): 8–10: 8–10: 9–10: 8–9: 8–10: 8–10: 4: 0; ♀, 10: (3)10–11(3): (3)6–8(3): 8–10: 8–10: 8–10: 9–10: 9–11: 9–10: 4: 0. Coxal chaetotaxy: ♂, 3: 4cs: 5: 5; ♀, 3–4: 4cs: 5: 5; coxae II with 5–7 distally incised spines set in oblique row; intercoxal tubercle absent. Genital opercula not unusual. Male genitalia (Fig. 22): ejaculatory atrium small, lateral apodeme meeting in mid-line; lateral margin of thickened roof of median diverticulum crenulate. Female genitalia (Fig. 20) with complete lateral apodeme frame, although anterior margin very faint; lateral diverticulum covered with cribriform plates in central section. Spiracles with stigmatic helix. Legs: heterotarsate; arolium slightly shorter than claws; claws simple.

Dimensions (mm), ♂ (♀): body length 0.88–0.98 (0.94–1.10); pedipalps: trochanter 0.115–0.13/0.07–0.075 (0.115–0.14/0.07–0.085), femur 0.32–0.345/0.07–0.075 (0.345–0.375/0.075–0.085), tibia 0.145–0.16/0.07–0.08 (0.15–0.165/0.08–0.09), chela 0.48–0.505/0.09 (0.505–0.56/0.10–0.11), moveable finger length 0.27–0.29 (0.275–0.32), hand length 0.205–0.215 (0.21–0.23); chelicera 0.24–0.255/0.12–0.135 (0.27–0.29/0.14–0.16), moveable finger length 0.12–0.14 (0.14–0.16); carapace 0.27–0.295/0.29–0.315 (0.29–0.305/0.315–0.34); leg I: trochanter 0.085/0.07 (0.09–0.095/0.07–0.075), basifemur 0.175–0.20/0.045–0.05 (0.185–0.21/0.045–0.05), telofemur 0.09–0.11/0.04–0.045 (0.095–0.115/0.04–0.045), tibia 0.095–0.11/0.03 (0.095–0.12/0.035), tarsus 0.19–0.205/0.025–0.03 (0.19–0.235/0.03); leg IV: trochanter 0.11/0.075 (0.105–0.13/0.08–0.095), basifemur 0.145–0.165/0.15–0.165 (0.16–0.175/0.145–0.16), telofemur 0.225–0.25/ 0.13–0.16 (0.235–0.25/0.14–0.155), tibia 0.21–0.23/0.055–0.065, basitarsus 0.095–0.105/0.04–0.045 (0.10–0.115/0.045–0.05), telotarsus 0.205–0.225/0.025–0.03 (0.215–0.25/0.025–0.03).

Tritonymphs: colour pale. Pedipalp: trochanter 1.46–1.67, femur 3.77–4.17, tibia 1.71, chela 4.53–5.07, hand 2.00–2.13 times as long as broad. Fixed chelal finger with 7 trichobothria, moveable chelal finger with 3 trichobothria; *isb* and *sb* absent (Fig. 16). Fixed chelal finger with 12 teeth, without intercalary teeth, moveable chelal finger with 6 teeth, without intercalary teeth. Chelicera with 5 setae on hand; flagellum of 5 pinnate blades. Carapace 1.07–1.23 times as long as broad; with m4m: 4: 4: 2: 2 setae. Tergal chaetotaxy: 4: 4: 4: 4–6: 5: 6: 5–6: 5: 5: 4: 4: 0. Sternal chaetotaxy: 5: (2)6(2): (2)6(2): 6–7: 7: 7: 7: 6–7: 7: 0: 2. Coxal chaetotaxy: 3: 3cs: 4: 4; coxae II with 5 distally incised spines. Heterotarsate.

Dimensions (mm): body length 0.67–0.73; pedipalps: trochanter 0.095–0.10/0.06–0.065, femur 0.245–0.25/0.06–0.065, tibia 0.12/0.07, chela 0.38–0.385/0.075–0.085, moveable finger length 0.215–0.225, hand length 0.16–0.17; carapace 0.245/0.20–0.23.

Deutonymphs: colour pale. Pedipalp: trochanter 1.50–1.60, femur 3.27–3.60, tibia ?, chela 4.38–4.58, hand 1.85–2.42 times as long as broad. Fixed chelal finger with 6 trichobothria, moveable chelal finger with 2 trichobothria; *esb*, *isb*, *sb* and *b* absent. (Fig. 17). Fixed chelal finger with 9 teeth, without intercalary teeth, moveable chelal finger with 5–6 teeth, without intercalary teeth. Chelicera with 4 setae on hand; flagellum of 5 pinnate blades. Carapace 1.00–1.03 times as long as broad; with m4m: 4: 4: 2: 2 setae. Tergal chaetotaxy: 4: 4: 4: 4: 4: 4: 4: 4: 4: 4: 2: 0. Sternal chaetotaxy: ? Coxal chaetotaxy: 2: 3cs: 3: 3; coxae II with 4 distally incised spines. Heterotarsate.

Dimensions (mm): body length 0.51; pedipalps: trochanter 0.075–0.08/0.05, femur 0.18/0.05–0.055, tibia ?, chela 0.275–0.285/0.06–0.065, moveable finger length 0.17, hand length 0.12–0.145; carapace 0.195–0.21/0.19–0.21.

Etymology. "Kapi" is the name used in the ancient Javanese book "Pustaka Raja" ("Book of Kings") for Krakatau. "Kapi" erupted in A.D. 416 (Judd, 1889). It is to be treated as an indeclinable noun.

Remarks. The "tubercle-like sensorium" of the tip of the fixed chelal finger reported for the male holotype of *Lagynochthonius bakeri* (Chamberlin) by Chamberlin (1962) is present in all the males of the genus that I have examined, yet is absent from the females. I cannot detect a similar structure in

the males of various species of *Tyrannochthonius* I have examined, and thus the character appears to be diagnostic for males of the genus *Lagynochthonius*.

Lagynochthonius johni (Redikorzev)

Figures 23–29

Chthonius johni Redikorzev, 1922: 550–554, figs 5–9.

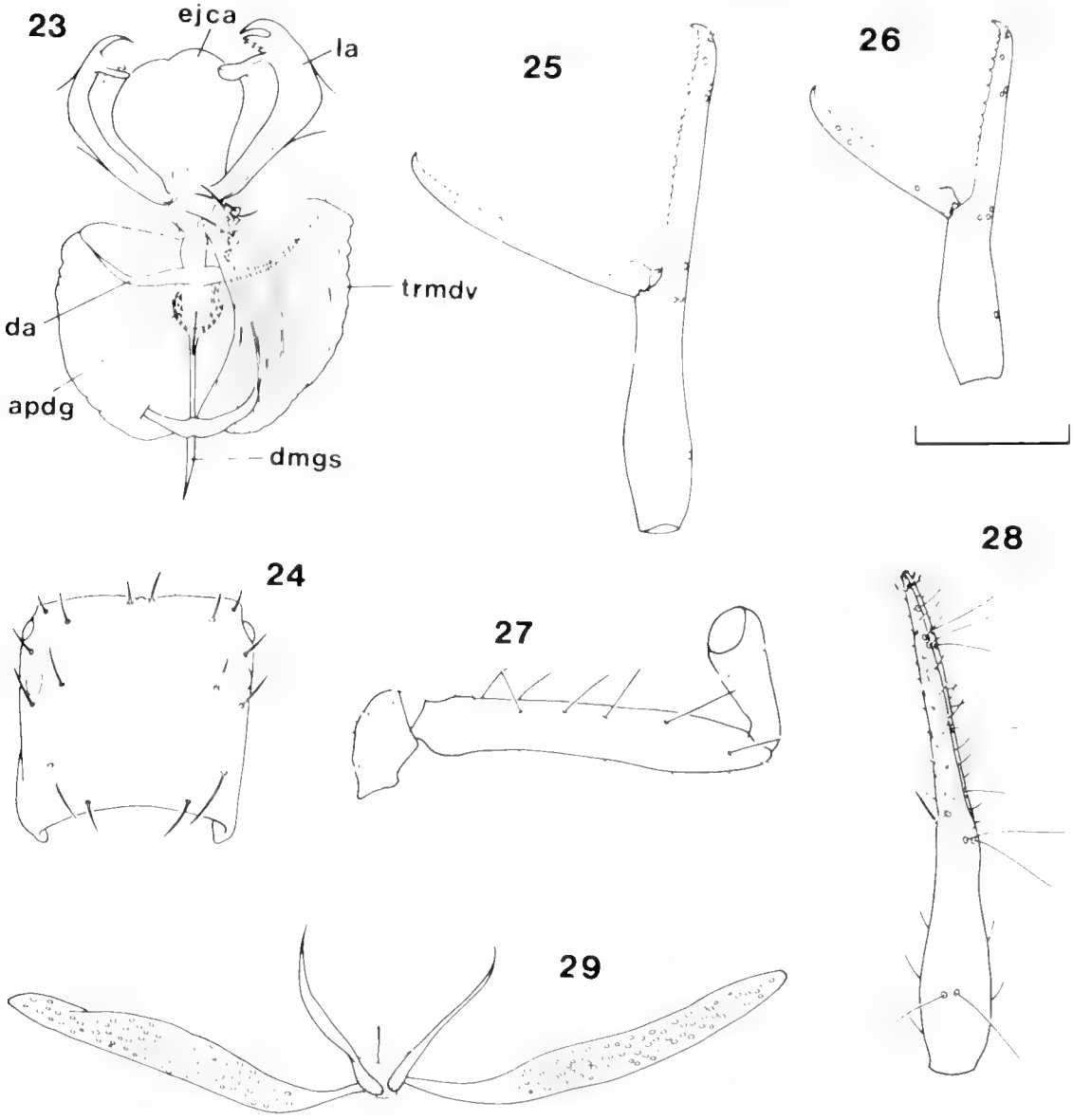
Tyrannochthonius johni (Redikorzev). – Chamberlin, 1929: 75.

Tyrannochthonius (Lagynochthonius) johni (Redikorzev). – Beier, 1966b: 340.

Lagynochthonius johni (Redikorzev). – Chamberlin, 1962: 314.

Type material. Holotype ♂, Siak, Sumatra, 21 Apr 1913, O. John (ZIL?, not examined).

Other material examined. Java. Ujung Kulon, Pulau



Figures 23–29. *Lagynochthonius johni* (Redikorzev). Figs 23, 25, 27, 28, male, MH815.01. Fig. 24, male, MH816.03. Fig. 26, tritonymph, MH815.03. Fig. 29, female, MH815.02. Fig. 23, genitalia, ventral, detail of trmdv not shown in right half. Fig. 24, carapace. Fig. 25, left chela, lateral. Fig. 26, left chela, lateral. Fig. 27, right pedipalp, dorsal. Fig. 28, right chela, dorsal. Fig. 29, genitalia, ventral. Scale line = 0.09 mm (Fig. 23), 0.20 mm (figs 24–28), 0.06 mm (fig. 29).

Peucang, 5°45'S, 105°15'E, litter, 19 Sep 1984, 1 ♂, 1 ♀, 1 tritonymph (MZB, 119-Q, MH815.01-03, SL); same data, 1 ♂, 2 tritonymphs (NMV, 119-AN, MH816.03-05, SL).

Diagnosis. The only other species of the genus of comparable size and with such a slender chela are *L. tonkinensis* (Beier), *L. novaeguineae* (Beier) and *L. arctus* (Beier). The latter possesses a much more slender chela, while the other two have fewer teeth on the chelal fingers.

Description. Adults: colour pale yellow-brown, pedipalps and carapace slightly darker. Setae acuminate. Pleural membrane papillo-striate. Pedipalp (Figs 27–28): trochanter 1.67–2.07 (♂), 1.76 (♀), femur 5.94–6.18 (♂), 5.75 (♀), tibia 2.31–2.59 (♂), 2.38 (♀), chela 6.70–7.20 (♂), 5.85 (♀), hand 3.25–3.35 (♂), 2.74 (♀) times as long as broad. Fixed chelal finger and hand with 8 trichobothria, moveable chelal finger with 4 trichobothria (Fig. 25); *ib* and *isb* on dorsum of hand, *st* close to *t*. Hand with 1 medial acuminate spine-like seta at level of *ist*. Venom apparatus absent. Chelal teeth: fixed finger with 19–20 (♂), 19 (♀) large, well-spaced, slightly retrorse teeth, plus 7–8 (♂), 9 (♀) small intercalary teeth between anterior teeth, and several low, rounded teeth basally; moveable finger with 8–9 (♂), 8 (♀) well-spaced teeth in anterior half, plus 6 (♂, ♀) small intercalary teeth between anterior teeth, remaining teeth low and rounded; terminal tooth of moveable finger not appearing hooked. Fixed finger with small distal sensorium near *ds* in male only. Moveable finger longer than hand; hand strongly constricted distally; moveable chelal finger with large basal apodeme. Chelicera with 5 setae on hand, all acuminate; flagellum of 7 blades; moveable finger with 1 seta; galeal region a very low elevation. Carapace (Fig. 24) 0.91–0.96 (♂), 0.84 (♀) times as long as broad; 4 corneate eyes; epistome very low, with 2 closely appressed setae; with 4: 4: 4: 2: 2 setae. Tergites and sternites undivided. Tergal chaetotaxy: ♂, 4: 4: 4: 4: 4: 4: 4–5: 5: 5: 4: 4: 0; ♀, 4: 4: 4: 4: 4: 5: 5: 5: 5: 4: 4: 0. Sternal chaetotaxy: ♂, 10–11: (4)30–31 [8] (4): (4)7–8(4): 9–10: 9–10: 9: 9–10: 9: 9: 4: 2; ♀, 11: (4)10(4): (4)6(4): 9: 9: 9: 9: 9: 7: 4: 2. Coxal chaetotaxy: ♂, ♀, 3: 4cs: 5: 5; coxae II with 9–10 (♂, ♀) distally incised spines set in oblique row; intercoxal tubercle absent. Genital opercula not unusual. Male genitalia (Fig. 23): ejaculatory atrium large; lateral apodemes not meeting in midline; lateral margin of thickened roof of median diverticulum only slightly undulate. Female genitalia (Fig. 29) with incomplete lateral apodeme frame; lateral diverticulum elongate, evenly covered with cribriform plates. Spiracles with stigmatic helix. Legs: heterotarsate, arolium slightly shorter than claws; claws simple.

Dimensions (mm), ♂ (♀): body length 1.08–1.21 (1.195); pedipalps: trochanter 0.14–0.165/ 0.085–0.095 (0.185/0.105), femur 0.475–0.525/ 0.08–0.085 (0.575/0.10), tibia 0.185–0.22/ 0.08–0.085 (0.25/0.105), chela 0.67–0.72/0.10 (0.79–0.795/135), moveable finger length 0.36–0.39 (0.415–0.425), hand length 0.32–0.335 (0.37–0.385); chelicera 0.295–0.31/0.155–0.16 (0.36/0.19), moveable finger length 0.16 (0.205); carapace 0.305–0.325/0.335–0.34 (0.345/0.41); leg I: trochanter 0.10–0.11/0.085–0.09 (0.12/0.095), basifemur 0.245–0.265/0.05–0.055 (0.295/0.06), telofemur 0.14–0.145/0.045–0.05 (0.16/0.05), tibia 0.125–0.145/0.04 (0.165/0.04), tarsus 0.27–0.275/0.03 (0.27/0.04); leg IV: trochanter 0.095–0.14/ 0.095–0.10 (0.165/0.10), basifemur 0.205–0.21/0.175–0.185 (0.225/ 0.19), telofemur 0.32–0.37/0.17–0.18 (0.38/0.185), tibia 0.29–0.30/0.06 (0.33/0.07), basitarsus 0.13–0.145/ 0.045–0.05 (0.155/ 0.055), telotarsus 0.31–0.33/ 0.03 (0.34/0.03).

Tritonymph: colour much paler than adults. Pedipalp: trochanter 1.71–1.79, femur 4.77–5.00, tibia 1.93–2.07, chela 5.88, hand 2.82 times as long as broad. Fixed chelal finger with 7 trichobothria, moveable chelal finger with 3 trichobothria; *isb* and *sb* absent (Fig. 26). Fixed chelal finger with 16 teeth, plus 7 small intercalary teeth distally. Moveable chelal finger with 7–8 teeth. Chelicera with 5 setae on hand; flagellum of 6 pinnate blades. Carapace 1.00 times as long as broad; with 4: 4: 4: 2: 2 setae. Tergal chaetotaxy: 4: 4: 4: 4: 4: 4: 5: 5: 5: 4: 4: 0. Sternal chaetotaxy: 5: (2)7(2): (2)6(2): 7: 7: 7: 8: 7: 7: 2: 2. Coxal chaetotaxy: 3: 3cs: 4: 4; coxae II with 6–7 distally incised spines. Heterotarsate.

Dimensions (mm): body length 0.635–0.75; pedipalps: trochanter 0.12–0.125/0.07, femur 0.31–0.35/0.065–0.07, tibia 0.145/0.07–0.075, chela 0.50/0.085, moveable finger length 0.255–0.275, hand length 0.24–0.25; carapace 0.25/0.25.

Remarks. Lagynochthonius johni is the type species of the genus and was originally described from a single male collected from Siak, in east-central Sumatra (Redikorzev, 1922). Two other collections have been recorded in the literature as this species. The first was a short series from Java (Beier, 1930, 1932b), which Chamberlin (1962) regarded as representing a new species distinct from *L. johni*

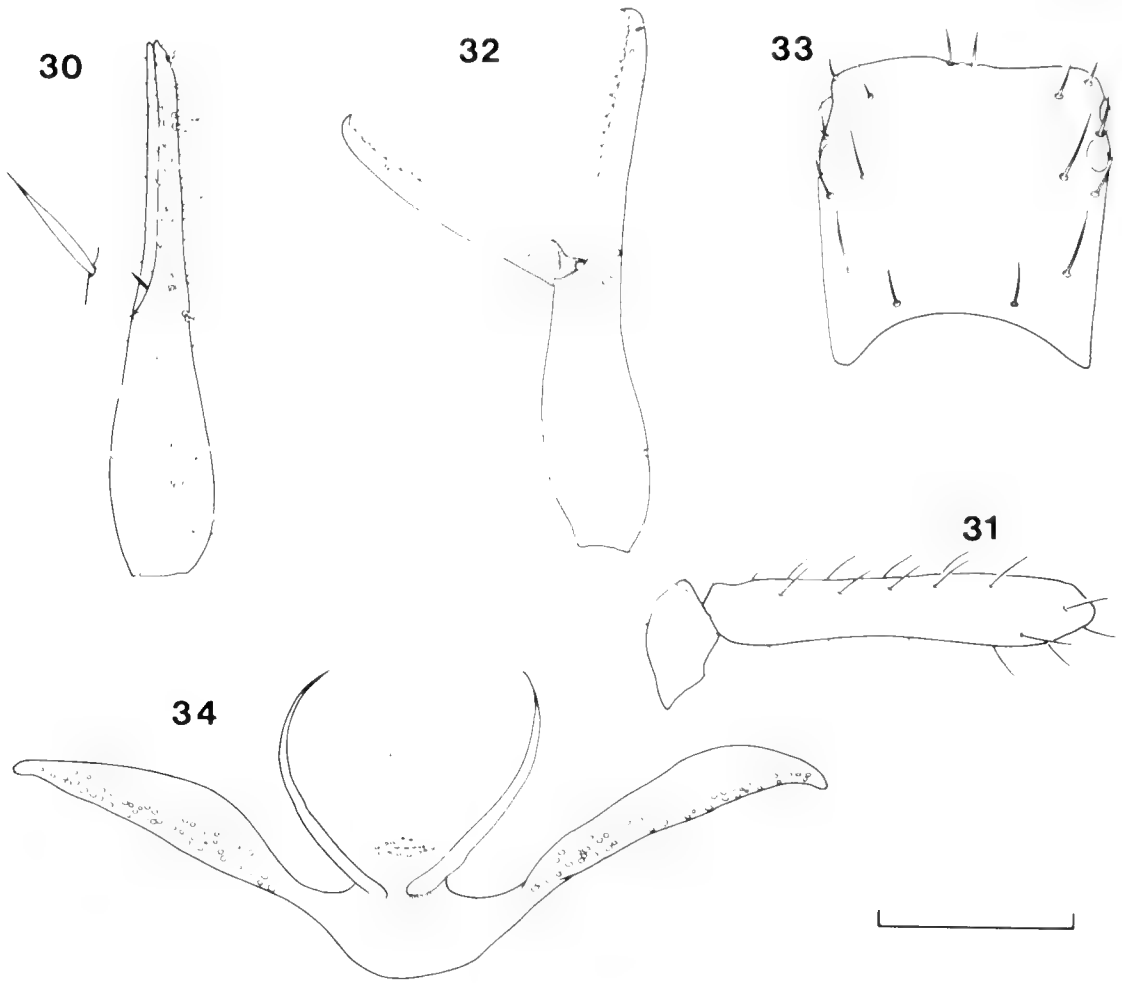
which he named *L. roeweri* Chamberlin. Unlike Chamberlin, I have had the opportunity to examine the type material of *L. roeweri* which is lodged in SMF. Chamberlin's assessment is quite correct. The second collection of *L. johni* was a single female from the Philippines (Beier, 1966b); the specimen was not described.

While I have not had the opportunity to examine the holotype of *L. johni,* the description by Redikorzev (1922) is generally accurate and I have few reservations in assigning the specimens from Ujung Kulon to this species. The following discrepencies between Redikorzev's description and the Ujung Kulon specimens are noted: (1) Redikorzev (1922, fig. 5) depicted the epistome as a large blunt trapezoidal projection, with the anterior eye placed at the edge of the carapace. Redikorzev seems to have mistaken the posterior edge of the chelicerae for the anterior margin of the carapace and thus drawn the epistome far too large and the eyes too close to the anterior margin of the carapace. (2) The dentition of the cheliceral fingers is slightly different, but I prefer to ascribe this to intraspecific variation, especially as the dentition varies within individuals. (3) The very low carapaceal and tergal chaetotaxies recorded for the holotype by Redikorzev (1922) is probably incorrect and, as noted by Chamberlin (1962), setae may have been lost from from the specimen.

Lagynochthonius thorntoni sp. nov.

Figures 30–34

Type material. Holotype ♀, Pulau Peucang, Ujung Kulon, Java, 5°45'S, 105°15'E, under bark of log on



Figures 30–34. *Lagynochthonius thorntoni* sp. nov., holotype female. Fig. 30, right chela, dorsal. Fig. 31, trochanter and femur of right pedipalp, dorsal. Fig. 32, left chela, lateral. Fig. 33, carapace. Fig. 34, genitalia, ventral. Scale line 0.25 mm (figs 30–33), 0.07 mm (fig. 34).

beach, 19 Sep 1984 (MZB, 17-C, MH814.01, SL).

Diagnosis. This is the only described species of the genus with a lanceolate chelal spine-like seta.

Description. Female only. Colour pale yellow-brown, pedipalps and carapace slightly darker. Setae acuminate. Pleural membrane papillo-striate. Pedipalp (Figs 30, 31): trochanter 1.80, femur 5.63–5.74, tibia ?, chela 5.21, hand 2.64 times as long as broad. Fixed chelal finger and hand with 8 trichobothria, moveable chelal finger with 4 trichobothria; *ib* and *isb* on dorsum of hand, *st* close to *t* (Fig. 32). Hand with 1 medial lanceolate spine-like seta at level of *ist* (Fig. 30). Venom apparatus absent. Chelal teeth: fixed finger with 17 large, well-spaced, slightly retrorse teeth, plus 9 small intercalary teeth between anterior teeth; moveable finger with 7 well-spaced teeth in anterior half, plus 2 small intercalary teeth between anterior teeth, remaining teeth low and rounded; terminal tooth of moveable finger not appearing hooked. Fixed finger without distal sensorium near *ds*. Moveable finger approximately same length as hand; hand constricted distally; moveable chelal finger with large basal apodeme. Chelicera with 5 setae on hand, *bs* lanceolate, remainder acuminate; flagellum of 8 blades; moveable finger with 1 seta; galeal region a very low elevation. Carapace (Fig. 33) 0.87 times as long as broad; 4 corneate eyes; epistome very low, with 2 closely appressed setae; with 4: 4: 4: 2: 2 setae. Tergites and sternites undivided. Tergal chaetotaxy: 4: 4: 4: 4: 5: 7: 6: 6: 5: 4: 4: 0. Sternal chaetotaxy: 10: (4)8(4): (3)6(3): 10: 10: 11: 11: 11: 9: 0: 2. Coxal chaetotaxy: 3: 4cs: 5: 5; coxae II with 8 distally incised spines set in oblique row; intercoxal tubercle absent. Genital opercula not unusual. Female genitalia (Fig. 34) with rounded lateral apodeme frame, the base of which appears to possess muscle attachment sites; lateral diverticula moderately large with lateral cribriform plate on posterior half; posterior diverticulum moderately large. Spiracles with stigmatic helix. Legs: heterotarsate, arolium slightly shorter than claws; claws simple.

Dimensions (mm): body length 1.13; pedipalps: trochanter 0.18/0.10, femur 0.535–0.545/0.095, tibia ?/?, chela 0.73–0.745/0.14, moveable finger length 0.36–0.375, hand length 0.36–0.37; chelicera 0.33/0.18, moveable finger length 0.20; carapace 0.345/0.395; leg I: trochanter 0.11/0.10, basifemur 0.295/0.065, telofemur 0.155/0.05, tibia 0.16/0.04, tarsus 0.305/0.035; leg IV: trochanter ?/?, basifemur 0.225/0.20, telofemur 0.33/0.185, tibia 0.32/0.07, basitarsus 0.15/0.055, telotarsus 0.34/0.035.

Etymology. The specific epithet is for Prof. I.W.B. Thornton, leader of the La Trobe University Krakatau Expeditions.

Remarks. The lanceolate form of both the spine-like chelal seta and cheliceral seta *bs* are unique.

Lagynochthonius hamatus sp. nov.

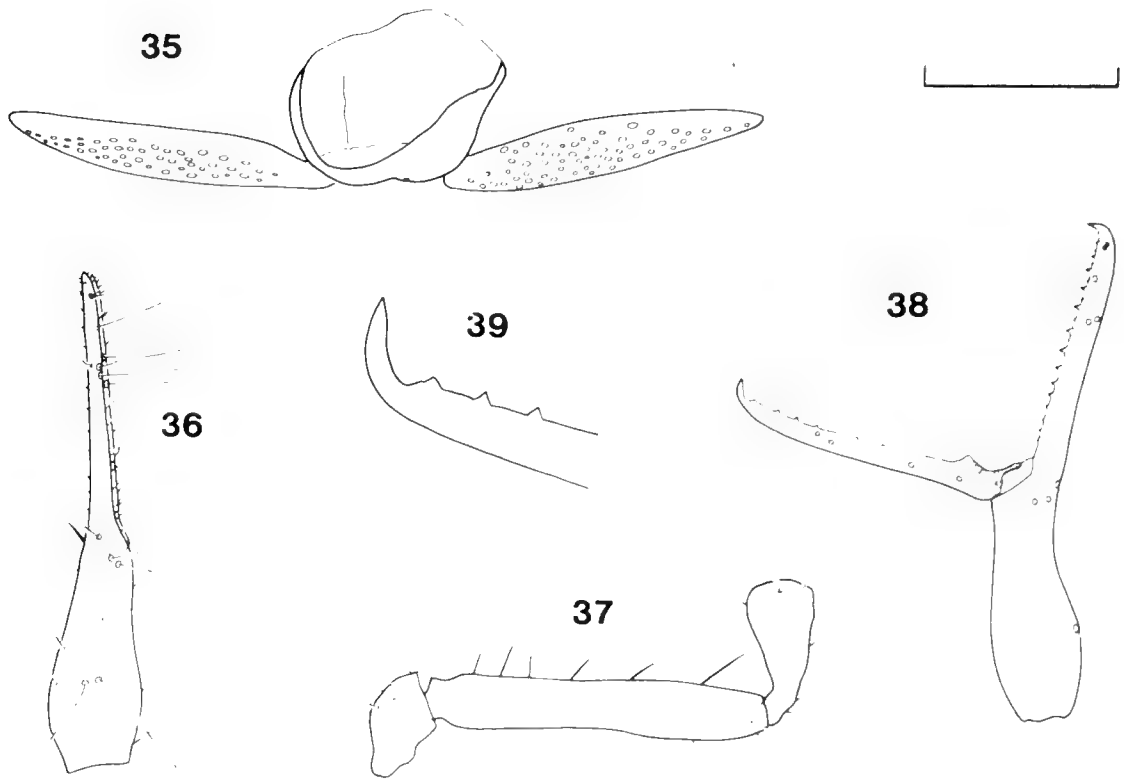
Figures 34–39

Type material. Holotype ♀, 7.5 km W of Liwa, Sumatra, 5°04'S, 104°03'E, 730 m, litter, 1 Sep 1984 (MZB, 91-M, MH807.14, SL).

Paratypes: 1 ♀ (without pedipalps), 1 tritonymph, same data as holotype (♀ in NMV, K743, tritonymph in MZB, 91-M, MH807.15-16, SL).

Diagnosis. This is the only species of the genus with a distinctly hooked terminal tooth of the moveable chelal finger.

Description. Female only. Colour pale yellow-brown, pedipalps and carapace slightly darker. Setae acuminate. Pleural membrane finely papillate. Pedipalp (Figs 36, 37): trochanter 1.71, femur 5.64, tibia 2.20, chela 5.65, hand 2.40 times as long as broad. Fixed chelal finger and hand with 8 trichobothria, moveable chelal finger with 4 trichobothria; *ib* and *isb* on dorsum of hand, *st* close to *t* (Fig. 38). Hand with 1 medial spine-like seta at level of *ist*. Venom apparatus absent. Chelal teeth: fixed finger with 15 large, well-spaced, slightly retrorse teeth, plus 5 small intercalary teeth between anterior teeth; moveable finger with 6 well-spaced teeth in anterior half, seventh tooth rounded, remaining teeth low and rounded; distal end of moveable finger with hooked terminal tooth (Fig. 39). Fixed finger without distal sensorium near ds. Moveable finger longer than hand; hand constricted distally; moveable chelal finger with large basal apodeme. Chelicera with 5 setae on hand, all acuminate; flagellum of 7 blades; moveable finger with 1 seta; galeal region a low elevation. Carapace 0.98 times as long as broad; 4 eyes, anterior pair corneate, posterior pair represented by faint eye spots; epistome very low, with 2 closely appressed setae; with 4: 4: 4: 2: 2 setae. Tergites and sternites undivided. Tergal chaetotaxy: 4: 4–5: 5–6: 5–6: 6: 6: 6: 7: 6: 4: 4: 0. Sternal chaetotaxy: 10–11: (4)10–14(4): (4)9–11(4): 9–10: 10–11: 10: 11: 9–10: 9: ?: 2. Coxal chaetotaxy: 3–4: 4cs: 5: 5; coxae II with 7 distally incised spines set in oblique row; intercoxal tubercle absent. Genital opercula not unusual. Female genitalia (Fig. 35) with thickened lateral apodeme frame; lateral diverticulum ovoid, nearly completely covered with lateral cribriform plates. Spiracles with stigmatic helix. Legs: heter-



Figures 35–39. *Lagynochthonius hamatus* sp. nov., holotype female. Fig. 35, genitalia, ventral. Fig. 36, right chela, dorsal. Fig. 37, trochanter, femur and tibia of right pedipalp, dorsal. Fig. 38, left chela, lateral. Fig. 39, distal end of moveable finger of left chela, lateral. Scale line 0.06 mm (figs 35, 39), 0.20 mm (figs 36–38).

otarsate; arolium slightly shorter than claws; claws simple.

Dimensions (mm): body length 0.87; pedipalps: trochanter 0.12/0.07, femur 0.395/0.07, tibia 0.16/0.075, chela 0.565/0.10, moveable finger length 0.315, hand length 0.24; chelicera 0.25/0.13, moveable finger length 0.14; carapace 0.275/0.28; leg I: trochanter 0.08/0.075, basifemur 0.205/0.045, telofemur ?/?, tibia 0.12/0.03, tarsus 0.225/0.025; leg IV: trochanter 0.13/0.09, basifemur 0.16/0.145, telofemur 0.25/0.14, tibia 0.235/0.055, basitarsus 0.11/0.045, telotarsus 0.25/0.03.

Tritonymph: Colour much paler than adults. Pedipalp: femur 5.30, chela 6.08, hand 2.77 times as long as broad. Fixed chelal finger with 7 trichobothria, moveable chelal finger with 3 trichobothria; *isb* and *sb* absent. Fixed chelal finger with 13 teeth, plus 2 small intercalary teeth distally. Chelicera with 5 setae on hand; flagellum of 7 pinnate blades. Carapace 1.00 times as long as broad; with 16 setae, including 4 on anterior margin and 2 on posterior margin. Tergal chaetotaxy: 4: 4: 4: 5: 5: 5: 5: 5: 5: 4: 4: 0. Sternal chaetotaxy: 5: (?)6(?): (1)6(1): 8 : 7: 7: 8: 7: 7: 2: 2. Coxal chaetotaxy: 3: 3cs: 4: 4; coxae II with 5 distally incised spines. Heterotarsate.

Dimensions (mm): body length 0.70; pedipalps: femur 0.265/0.05, chela 0.395/0.065, moveable finger length 0.22, hand length 0.18; carapace 0.225/0.225.

Etymology. The specific epithet refers to the hooked nature of the terminal tooth of the moveable chelal finger (Latin *hamatus*, hooked).

Garypidae

Garypus L. Koch

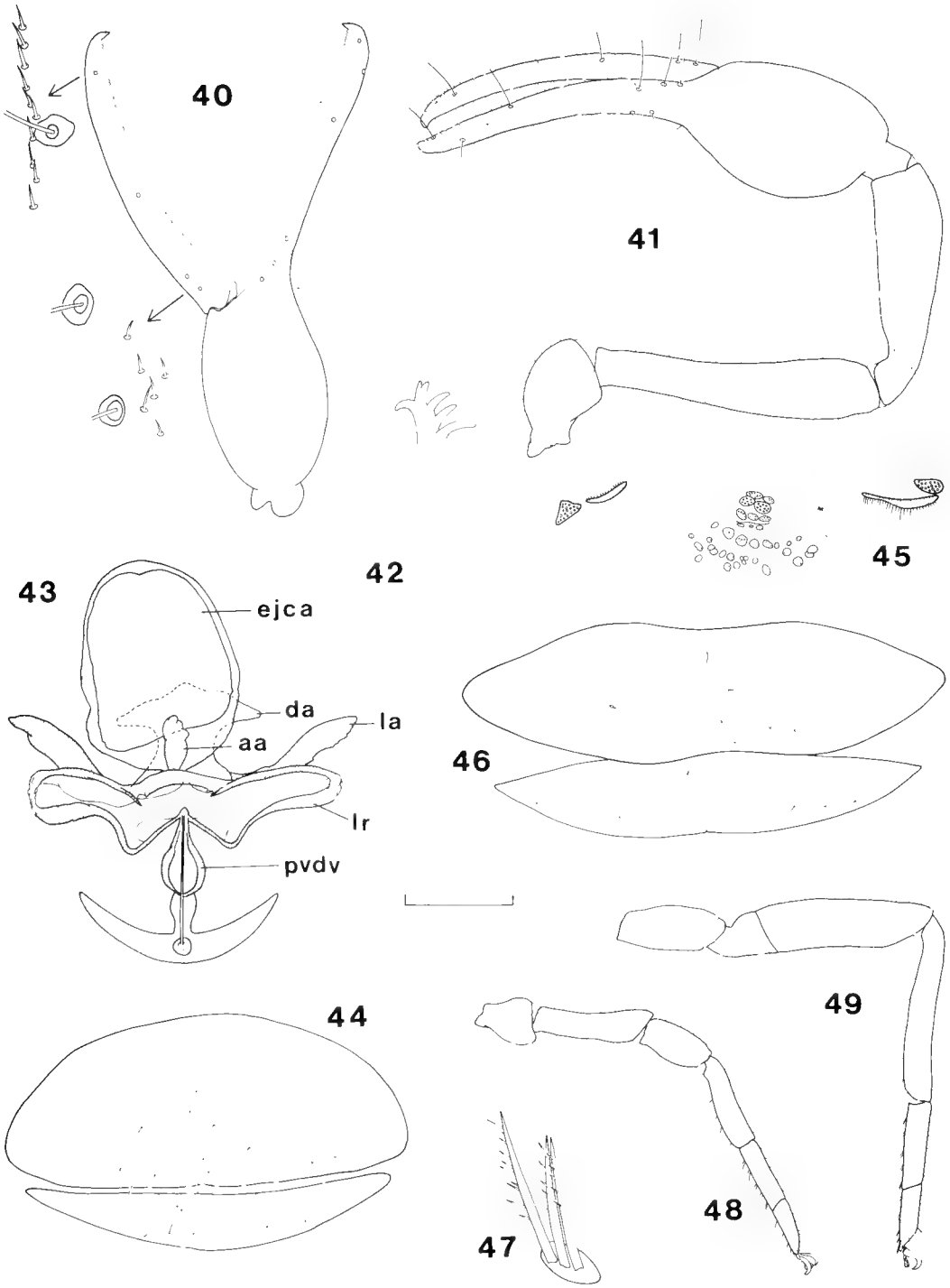
Garypus maldivensis Pocock

Figures 40–49

Garypus maldivensis Pocock, 1904: 798–799, figs 1a–e.—Chamberlin, 1930: 613, figs 1s, 1z.—Beier, 1932b: 222.—Beier, 1973: 45.–Mahnert, 1982: 310, fig. 9.

Type material. Lectotype ♀ [designated by Chamberlin (1930: 613); see below] , Midu Atoll, Maldive Islands (BMNH, 1924.11.3.44, JC-516.01001-3, SL).

Paralectotypes: 2 ♀, same data as lectotype (BMNH,



Figures 40–49. *Garypus maldivensis* Pocock. Figs 40–42, 45–49, female, MH827.02. Figs 43–44, male, MH827.01. Fig. 40, left chela, lateral, with detail of microsetae on moveable finger. Fig. 41, right pedipalp, dorsal. Fig. 42, galea. Fig. 43, genitalia, ventral. Fig. 44, genital opercula, ventral. Fig. 45, genitalia, ventral. Fig. 46, genital opercula, ventral. Fig. 47, flagellum. Fig. 48, left leg I. Fig. 49, left leg IV. Scale line = 0.66 mm (figs 40–41, 48–49), 0.07 mm (figs 42, 47), 0.10 mm (fig. 43), 0.17 mm (figs 44–45), 0.20 mm (fig. 46).

1924.11.3.46, 48, JC-516.01002-3, SL and SP).

Other material examined. Krakatau Islands. Rakata, Zwarte Hoek, 6°09'S, 105°25'E, under bark of dead *Barringtonia asiatica* on beach, 15 Sep 1984, 1 ♀, 1 ♂ (♀ in ZMB, ♂ in NMV, 172-M, MH827.01-02, SL).

Diagnosis. Without a complete revision of the Asian and Australian species assigned to this genus, it is impossible to distinguish *G. maldivensis* satisfactorily from other described species (see *Remarks* below).

Description. Colour: chela dark red-brown, remainder of pedipalps, carapace and tergites yellow-brown. Setae acarinate, generally acicular and straight, those of tergites, carapace and pedipalps often thicker and slightly curved. Pleural membrane wrinkled plicate, lacking investing setae. Pedipalp (Fig. 41) elongate: trochanter 1.73–1.83 (♂), 1.64–1.72 (♀), femur 4.96–5.15 (♂), 4.42–4.85 (♀), tibia 4.00 (♂), 3.44–3.74 (♀), chela (with pedicel) 4.60 (♂), 3.60–3.87 (♀), chela (without pedicel) 4.36 (♂), 3.41–3.66 (♀), hand 1.72 (♂), 1.41–1.43 (♀) times as long as broad. Fixed chelal finger with 8 trichobothria, moveable chelal finger with 4 trichobothria; *eb*, *esb* and *ist* in straight row, virtually equidistant, *ib* and *ist* adjacent, with *ib* dorsal to *ist*, *est*, it and *et* in distal third of finger, *it* closer to *et* than to *est*, *b* and *sb* basal, *st* slightly closer to *sb* than to *t*; patch of 6 lanceolate setae situated near *b*, and 10 near *t* (Fig. 40). Venom apparatus present in both fingers, terminating in nodus ramosus near *it* in fixed finger and proximal to *t* in moveable finger. Chelal teeth numerous, closely spaced and slightly retrorse. Chelicera with 5 setae on hand, all acuminate; serrula exterior with 26 (♂), 27–28 (♀) blades; flagellum of three blades, all with accessory spinules (Fig. 47); moveable finger with 1 seta; galea of male bifid, of female long with 5–6 distal rami (Fig. 42). Carapace 1.37 (♂), 0.96–1.08 (♀) times as long as broad; 2 transverse furrows present, anterior furrow very shallow; 4 eyes on ocular tubercles, posterior pair slightly smaller than anterior pair. Tergites II–X and sternites IV–X with broad division. Tergal chaetotaxy: ♂, 10: 11: 11: 12: 13: 14: 13: 15: 16: 16: 9: 2; ♀, 8–10: 13: 13–15: 12–14: 14–15: 15–22: 16–18: 16–18: 18–19: 15–16: 8–10: 2. Sternal chaetotaxy: ♂, 23: (0)7 [21] (0): (0)9(0): 10: 14: 15: 12: 12: 5: 4: 2; ♀, 10–14: (0)7–8(0): (0)7–12(0): 11–13: 14–20: 16–17: 15–17: 14–17: 11–14: 8–10: 2. Coxal chaetotaxy: ♂, 7–8: 9–10: 10: 18; ♀, 8–11: 11–12: 11–15: 20–28. Coxa IV wider than coxa I. Male genital opercula (Fig. 44): anterior operculum with very faint medial suture, posterior operculum narrow. Female genital operecula (Fig. 46) with incomplete, very faint medial sutures. Male genitalia (Fig. 43): lateral apodeme wing-shaped; anterior apodeme lobed; dorsal apodeme large; lateral rod moderately thin, ejaculatory atrium large. Female genitalia (Fig. 45): median cribriform plate apparently of 1 large plate with many fragmented regions of pores; muscle attachment plates present; spermathecae absent. Spiracles lacking stigmatic helix. Legs (Figs 48, 49): basifemur of legs I and II much longer than telofemur; diplotarsate, division between basitarsus and telotarsus slightly oblique; arolium shorter than claws; claws simple. Anal plate completely surrounded by sternite XI.

Dimensions (mm), ♂ (♀): body length 3.81 (5.19–5.77); pedipalps: trochanter 0.57–0.585/0.32–0.33 (0.715–0.79/0.435–0.48), femur 1.365–1.415/0.275 (1.68–1.875/0.375–0.395), tibia 1.18/0.295 (1.46–1.56/0.40–0.44), chela (with pedicel) 2.30/0.50 (2.95–3.10/ 0.78–0.82), chela (without pedicel) 2.18 (2.80–3.00), moveable finger length 1 29 (1.81–1.96), hand length 0.86 (1.10–1.175); chelicera 0.395/0.19 (0.565–0.58/0.265–0.275), moveable finger length 0.275 (0.385–0.40); carapace 1.12/0.815 (1.445–1.555/1.335–1.62), cucullus length 0.21 (0.21–0.32), ocular breadth 0.665 (0.84–0.925), anterior eye 0.12 (0.16–0.175), posterior eye 0.10 (0.125–0.15); leg I: trochanter 0.265/0.21 (0.385–0.415/0.28–0.315), basifemur 0.57/0.165 (0.70–0.735/0.205–0.225), telofemur 0.35/0.165 (0.45–0.495/0.21–0.23), tibia 0.445/0.12 (0.58–0.645/ 0.145–0.155), basitarsus 0.34 0.09 (0.445–0.455/0.11–0.13), telotarsus 0.315/0.09 (0.335–0.385/0.105–0.115); leg IV: trochanter 0.405/0.20 (0.63–0.67/0.265–0.305), basifemur 0.31/0.19 (0.445–0.47/0.235–0.265), telofemur 0.685/0.205 (1.07–1.19/0.28–0.305), tibia 0.685/0.135 (1.11–1.175/0.16–0.17), basitarsus 0.385/0.105 (0.565–0.58/0.135–0.145), telotarsus 0.32/ 0.095 (0.42–0.45/0.12–0.135).

Remarks. Pocock (1904) did not designate a holotype for *Garypus maldivensis* in the original description, but Chamberlin (1930), having examined the type specimens, nominated one as the holotype. As there is no reason to suppose that Pocock regarded this specimen as the holotype, it must be regarded as a lectotypic designation (Article 74b, International Code of Zoological Nomenclature, third edition).

There appears to be a certain amount of confusion regarding the classification of the Asian and Australian species of *Garypus*, mainly due to the small sample sizes (only *G. japonicus* Beier appears to have been collected on a frequent basis). Most

species have been distinguished on the relative sizes of the palpal segments, but until detailed work such as that by Wagenaar Hummelinck (1948) and Lee (1979) is completed, identifications must remain tentative. Nevertheless, the pair from Rakata are very similar to the types of *G. maldivensis* and are undoubtedly conspecific. The detailed structure of the male genitalia may serve to adequately distinguish species, but the only other figure of a *Garypus* species is that of *G. beauvoisii* (Audouin) by Vachon (1938, fig. 40) which is radically different to that of *G. maldivensis*.

Due to the presence of spinose flagellar blades, microsetae dorsal to *b*, only slightly oblique tarsal divisions and the absence of investing setae from the pleural membrane, *Garypus maldivensis* belongs to the "*giganteus*" species-group as defined by Lee (1979).

This species has only been found on Midu Atoll, Sri Lanka and now, Krakatau.

Geogarypidae

Geogarypus Chamberlin

Geogarypus javanus (Tullgren)

Figures 50–54

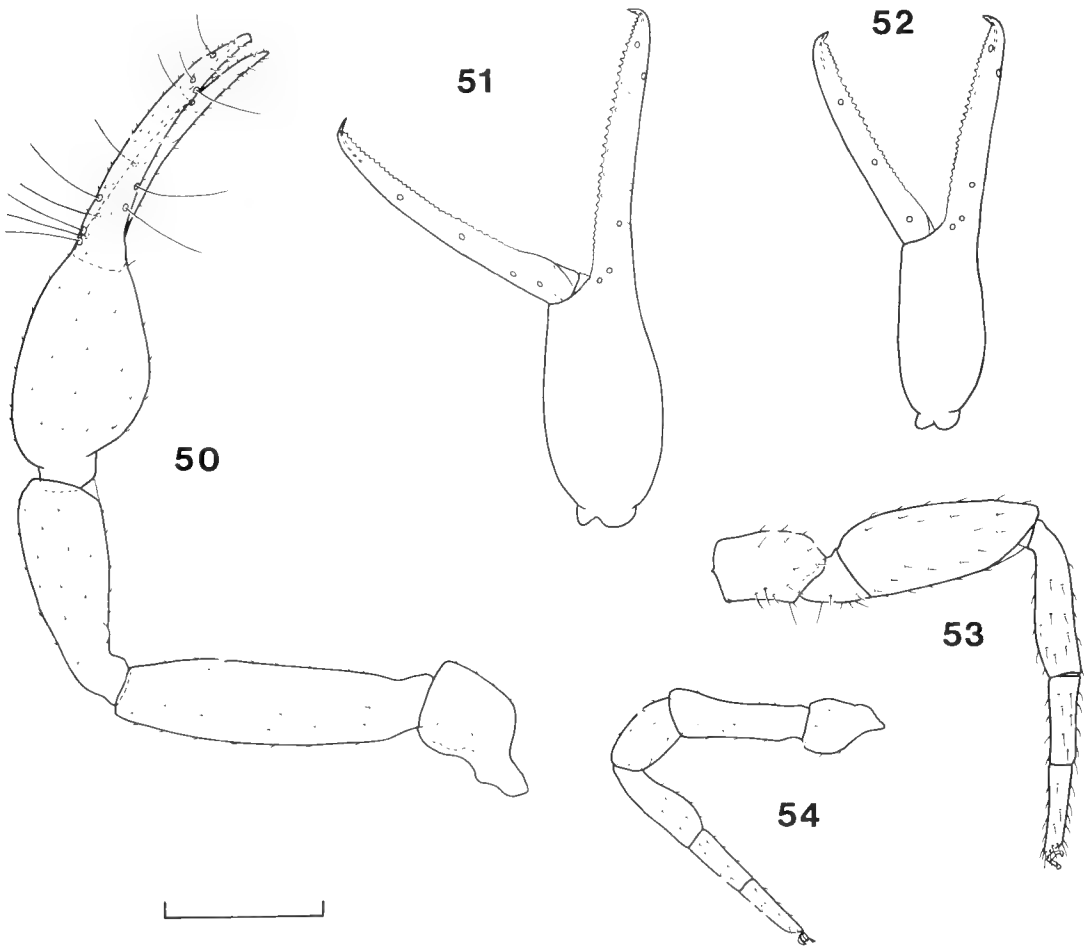
Garypus javanus Tullgren, 1905: 43–44.—Tullgren, 1907: 66.—Ellingsen, 1910: 388.

Geogarypus formosanus Beier, 1931: 315–316, fig. 10. Syn. nov.

Geogarypus (G.) formosanus.—Beier, 1932b: 232–233, fig. 260.

Geogarypus (G.) javanus.—Beier, 1932b: 233–234, fig. 261.

Geogarypus audyi Beier, 1952: 103–105, fig. 6. Syn. nov.



Figures 50–54. *Geogarypus javanus* (Tullgren). Figs 50, 54, holotype male. Figs 51, 53, male, MH813.01. Fig. 52, tritonymph, MH823.02. Fig. 50, left pedipalp, dorsal. Fig. 51, left chela, lateral. Fig. 52, left chela, lateral. Fig. 53, left leg IV. Fig. 54, left leg I. Scale line = 0.28 mm (fig. 50), 0.25 mm (figs 51–54).

Geogarypus javanus. – Beier, 1953: 82. – Weidner, 1959: 115. – Morikawa, 1963: 6-7. – Beier, 1982: 43.

Geogarypus (G.) javanus formosanus. – Beier, 1957: 21-24, figs 9a-b, 10a-d, 11a-d, 12e-f.

Geogarypus (G.) javanus audyi. – Beier, 1957: 25 (key).

Geogarypus (G.) javanus javanus. – Beier, 1957: 25 (key).

Geogarypus (G.) elegans audyi. – Beier, 1963: 507-508.

Geogarypus javanus javanus. – Beier, 1965: 764. – Beier. – 1966a: 140. – Beier, 1970: 318.

Geogarypus (G.) javanus takensis Beier, 1967: 352, fig. 12. Syn. nov.

Types. *Garypus javanus*: holotype male, Buitenzorg [now Bogor], Java, Farndetritus, Mar 1904 (ZMH, SP).

Geogarypus formosanus: holotype ♂, Takao [now Kaohsing], Formosa [now Taiwan], 27 Jan 1907, H. Sauter (ZMB, SP).

Geogarypus audyi: holotype ♂, Kuala Lumpur, Malaysia, in nest of *Rattus rattus diardi* (Jentink) [the label, in Beier's handwriting, indicates *Rattus rattus* as the host] (Muridae: Rodentia), 8 Dec 1949, [J.R.] Audy (NHMW, SP).

Geogarypus javanus takensis: holotype ♂, Langs weg var Tak noar Thoen, 65 km var. Tak, Thailand, 5 Dec 1957, I. D. Brongersma (RMNH, no. 312, SP).

Other material examined. Krakatau Islands. Rakata, Zwarte Hoek, 6°09'S, 105°25'E, 31 Aug 1984, 1 tritonymph (MZB, 104.8B, MH823.02, SL). Sertung, spit, 6°04'S, 105°24'-25'E, beating in transition zone, 18 Aug 1985, 1 ♂ (MZB, 244-BL, MH863.01, SL). Java, Ujung Kulon, Pulau Peucang, 6°45'S, 105°15'E, beating, rainforest, 19 Sep 1984, 1 ♂, 1 ♀ (NMV, 179-G, MH813.01-02, SL); same data except beating *Pandanus* sp., 1 ♀ (MZB, 179-Y, MH812.01, SL).

Diagnosis. The small size and uniform colour of the pedipalps distinguishes this species from its congeners.

Description. Adults: anterior portion of carapace dark brown, remaining area white; all pedipalpal segments brown. Pedipalp (Fig. 50): trochanter 1.45-1.65 (♂), 1.50-1.75 (♀), femur 3.32-3.56 (♂), 4.16-4.27 (♀), tibia 2.54-3.07 (♂), 2.79-2.91 (♀), chela (with pedicel) 3.58-3.92 (♂), 3.85-3.87 (♀), chela (without pedicel) 3.48-3.79 (♂), 3.72-3.75 (♀), hand 1.61 (♂), 1.64-1.65 (♀) times as long as broad. Fixed chelal finger with 8 trichobothria, moveable chelal finger with 4 trichobothria; *eb* and *esb* basal, *est* adjacent to *ib*, *st* midway between *sb* and *t* (Fig. 51). External face of fixed finger with 2 pit-like structures with raised rims below *esb* and *est*. Venom apparatus present in both chelal fingers; nodus ramosus distal. Fixed chelal finger with 33 (♂), 30 (♀) slightly curved marginal teeth, and 6 (♂), 10 (♀) internal accessory teeth; moveable chelal finger with 33 (♂), 36 (♀) marginal teeth. Chelicera with 5 setae on hand; serrula exterior with 16 (♂, ♀) lamellae; flagellum of 1 short aspinose blade; moveable finger with 1 distal seta; galea simple, with no rami. Carapace with 9-12 (♂), 12 (♀) setae on posterior margin, 0.86-0.97 (♂), 0.82-0.87 (♀) times as long as broad; 4 corneate eyes, approximately of similar size. Tergites and sternites not divided, but median sternites with very faint suture lines. Tergal chaetotaxy: ♂, 9-12: 10-13: 11: 10-12: 11-12: 12: 12-13: 13-14: 11-12: 6-9: 6-8: 2; ♀, 10-11: 11: 11-12: 11-13: 11-14: 3: 14: 12-13: 10-12: 8-9: 6-8: 2. Sternal chaetotaxy: ♂, 10-13: (1)4-11 [2-4] (1): (0)4(1): 12 : 14-16: 13-16: 14-16: 11-12: 6-10: 2: 0; ♀, 8: (1)2-3(1): (1)2-4(1): 8-10: 13-14: 12-14: 14-15: 10-12: 7-8: 2: 0. Coxal chaetotaxy: ♂, 6-8: 9-11: 15-17: 23-24; ♀, 9: 10-14: 17-19: 36-38. Genital opercula similar to those of *G. taylori* Harvey (Harvey, 1986, figs 11, 13). Male genitalia as in *G. taylori* (Harvey, 1986, fig. 12). Female genitalia: lateral cribriform plates elongate, 1 median cribriform plate. Spiracles with stigmatic helix. Legs (Figs 53-54): diplotarsate; basifemur of legs I and II longer than telofemur; arolium longer than claws; claws simple.

Dimensions (mm), ♂ (♀): body length 1.35-1.62 (1.83-1.91); pedipalps: trochanter 0.22-0.26/0.15-0.17 (0.28-0.285/0.16-0.19), femur 0.465-0.615/0.135-0.15 (0.645-0.705/0.155-0.165), tibia 0.355-0.445/0.14-0.16 (0.46-0.495/0.165-0.17), chela (with pedicel) 0.825-0.94/0.23-0.25 (1.04-1.065/0.27-0.275), chela (without pedicel) 0.80-0.91 (1.005-1.03), moveable finger length 0.47-0.55 (0.59-0.605), hand length 0.37 (0.445-0.45); chelicera 0.155-0.16/0.08-0.09 (0.095-0.10/0.095-0.10), moveable finger length 0.10-0.11 (0.115-0.12); carapace 0.50-0.575/0.515-0.625 (0.575-0.60/0.66-0.73), cucullus length 0.13-0.135 (0.15-0.17), ocular breadth 0.34-0.36 (0.37-0.385), anterior eye 0.05-0.075 (0.065), posterior eye 0.045-0.05 (0.06); leg I: trochanter 0.13-0.145/ 0.105-0.115 (0.155/0.125-0.135), basifemur 0.255-0.275/0.09-0.095 (0.30-0.325/0.105), telofemur 0.155-0.16/0.09 (0.18-0.185/0.095), tibia 0.185-0.205/0.06-0.065 (0.225/0.07), basitarsus 0.12-0.145/ 0.05 (0.16/0.05-0.055), telotarsus 0.13-0.145/0.04 (0.14/0.035-0.045); leg IV: trochanter 0.20/0.115 (0.24-0.255/0.13-0.14), basifemur 0.125/0.09 (0.155-0.16/0.10-0.105), telofemur 0.35/0.135 (0.43-0.45/0.155-0.16), tibia 0.285/0.075 (0.345/0.085-0.09), basitarsus 0.155/0.055 (0.19-0.195/0.06-0.065), telotarsus 0.155/0.045 (0.18-0.185/0.045-0.05).

Tritonymph: colour pale, but all pedipalpal segments brown. Pedipalp: trochanter 1.60, femur

3.95, tibia 2.74, chela (with pedicel) 4.21, chela (without pedicel) 4.06, hand 1.76 times as long as broad. Fixed chelal finger with 7 trichobothria, moveable chelal finger with 3 trichobothria; *isb* and *sb* absent (Fig. 52). Serrula exterior of chelicera with 13 lamellae; galea long with 5 distal to subdistal rami. Carapace with 7 setae on posterior margin; 0.86 times as long as broad. Tergal chaetotaxy: 8: 7: 8: 9: 8: 8: 8: 8: 7: 6: 6: 2. Sternal chaetotaxy: 2: (1)2(1): (1)3(1): 8: 8: 8: 9: 6: 6: 2: 0. Coxal chaetotaxy: 5: 7: 9: 16. Diplotarsate.

Dimensions (mm): body length 1.18; pedipalps: trochanter 0.20/0.125, femur 0.435/0.11, tibia 0.315/0.115, chela (with pedicel) 0.695/0.165, chela (without pedicel) 0.67, moveable finger length 0.405, hand length 0.29; carapace 0.43/0.50.

Remarks. The type material of *Garypus javanus*, *Geogarypus formosanus*, *G. audyi* and *G. javanus takensis* have been examined and there can be no doubt that they are all conspecific. The male holotypes of the three former species are virtually identical in size; the holotype of *G. javanus takensis* is slightly smaller, but well within the range usually accorded to species. The male from Ujung Kulon is intermediate in size between the latter and the other three holotypes. I can detect no consistent characters that would warrant the maintenance of separate species or subspecies, and therefore reduce to synonymy the three later names. The male holotype of *G. javanus* was incorrectly considered by Tullgren (1905) to be a juvenile.

Geogarypus micronesiensis Morikawa was described from a single female from Marcus Island (Morikawa, 1952) and bears a striking resemblance to *G. javanus*. It is of similar size (Morikawa reports a femur length of 0.66 mm) and were it not for a differently coloured carapace (Morikawa, 1952, fig. 4), I would consider them conspecific. Examination of the holotype is necessary before a definite decision can be made.

Geogarypus javanus is widely distributed in South-east Asia and has been recorded from the following countries: Thailand, Malaysia, Taiwan, Papua New Guinea (New Britain, Bismark-Archipelago), Indonesia (Java, West Sumba, Irian Jaya), Solomon Islands, and many islands in Micronesia.

Geogarypus albus Beier

Figures 55–58

Geogarypus albus Beier, 1963: 508–510, fig. 1.—Tenorio and Muchmore, 1982: 382.

Type material. Holotype ♂, Rantau Panjang, 8 km N of Klang, Selangor, Malaysia, ex nest no. 65 of *Microscelis olivacea* Blyth (Pycnonotidae: Aves), 1960, H.E. McClure and Lim Boo-Liat (BPBM, 3464, not examined). Allotype ♀, same data as holotype except nest no. 62 (BPBM, not examined).

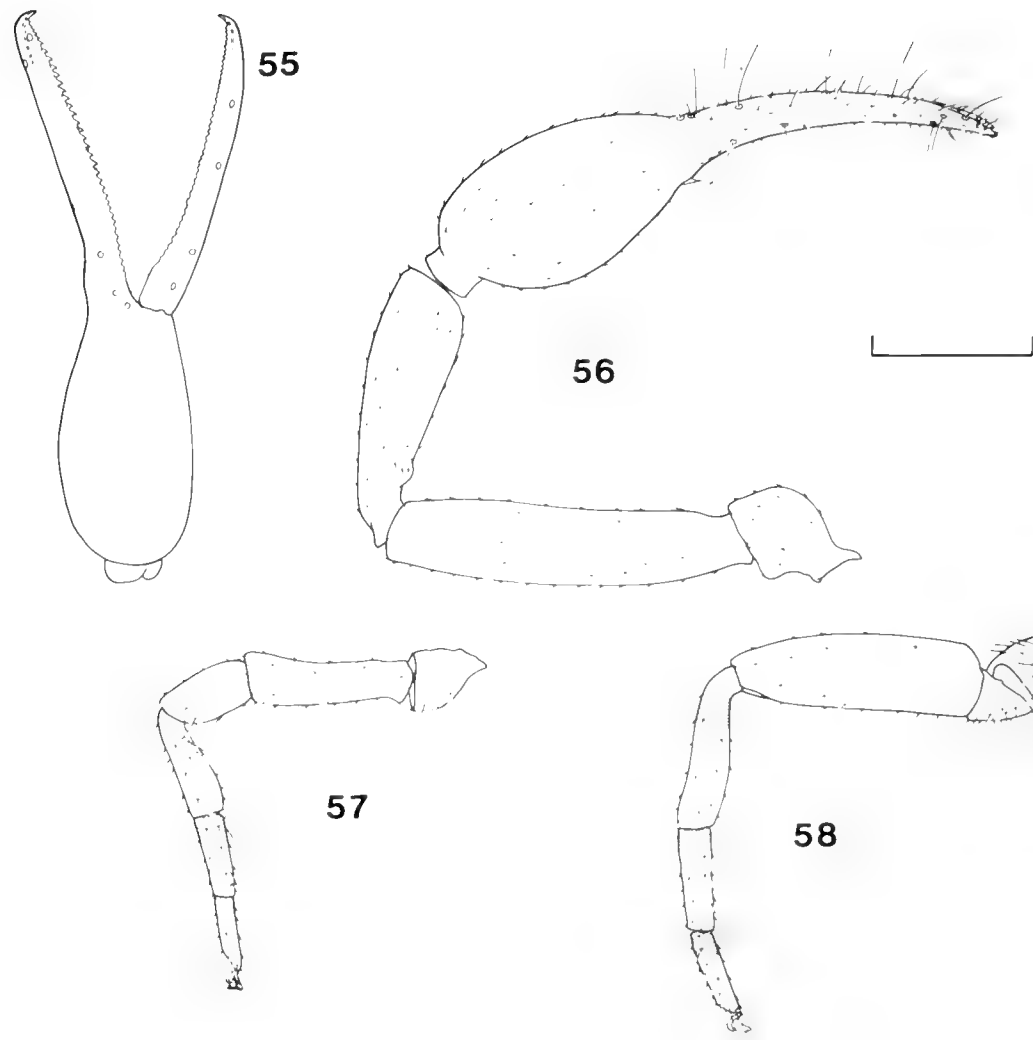
Paratypes: 1 ♀, same data as holotype except nest no. 26 (BPBM?, not examined); 1 ♂, same data as holotype except 22 Feb 1961, nest no. 69 (BPBM?, not examined); 1 ♂, same data as holotype except nest no. 111 (BPBM?, not examined); 1 ♀, 1 deutonymph, same data as holotype except nest no. 193 (BPBM?, not examined).

Material examined. Java. Ujung Kulon, Cibunar, 6°48'S, 105°17'E, litter, 20 Sep 1984, 1 ♀ (MZB, 18-B, MH817.01, SL).

Diagnosis. The large size and pale colour adequately distinguish this species.

Description. Female from Cibunar: colour as figured by Beier (1963); chela dark red-brown, remaining pedipalpal segments nearly white, even though some brown is apparent; legs banded as in Figs 57–58. Pedipalp (Fig. 56): trochanter 1.51, femur 4.66–4.78, tibia 3.18–3.24, chela (with pedicel) 3.96, chela (without pedicel) 3.81, hand 1.67 times as long as broad. Fixed chelal finger with 8 trichbothria, moveable chelal finger with 4 trichobothria; *eb* and *esb* basal, *est* slightly anterior to *ib*, *st* slightly closer to *t* than to *sb* (Fig. 55). External face of fixed finger with 18 pit-like structures with raised rims along face of finger. Venom apparatus present in both fingers; nodus ramosus distal. Fixed chelal finger with 36 well-spaced, slightly retrorse marginal teeth, plus 15 internal accessory teeth; moveable finger with 39 marginal teeth. Chelicera with 5 setae on hand; serrula exterior with 19–20 lamellae; flagellum of 1 aspinose blade; moveable finger with 1 distal seta; galea simple, with no rami. Carapace with 11 setae on posterior margin, 1.10 times as long as broad; 4 eyes, anterior pair slightly larger than posterior pair. Tergites and sternites not divided, but median sternites with a very faint suture line. Tergal chaetotaxy: 14: 14: 15: 18: 19: 20: 18: 16: 14: 12: 6: 2. Sternal chaetotaxy: 10: (2)2(2): (2)6(2): 16: 16: 15: 16: 16: 12: 2: 0. Coxal chaetotaxy: 8: 9: 16: 42. Genital opercula similar to those of *G. taylori* (Harvey, 1986, fig. 13). Female genitalia with elongate lateral cribriform plates and 1 rounded median cribriform plate. Spiracles with stigmatic helix. Legs (Figs 57, 58): diplotarsate; trochanter and basifemur of leg IV with many long setae; basifemur of legs I and II longer than telofemur; arolium longer than claws; claws simple.

Dimensions (mm): body length 2.67; pedipalps: trochanter 0.37/0.245, femur 0.955–0.98/0.205, tibia 0.715–0.73/0.225, chela (with pedicel) 1.485/0.375, chela (without pedicel) 1.43, movea-



Figures 55–58. *Geogarypus albus* Beier, female, MH817.01. Fig. 55, right chela, lateral. Fig. 56, left pedipalp, dorsal. Fig. 57, left leg I. Fig. 58, left leg IV. Scale line 0.40 mm.

ble finger length 0.83, hand length 0.625; chelicera 0.225/0.115, moveable finger length; carapace 0.92/0.84, cucullus length 0.21, ocular breadth 0.52, anterior eye 0.08, posterior eye 0.075; leg I: trochanter 0.21/0.16, basifemur 0.43/0.14, telofemur 0.245/0.135, tibia 0.30/0.095, basitarsus 0.225/0.08, telotarsus 0.195/0.055; leg IV: trochanter 0.34/0.19, basifemur 0.20/0.135, telofemur 0.635/0.20, tibia 0.44/0.11, basitarsus 0.275/0.09, telotarsus 0.245/0.06.

Remarks. Even though the specimen from Java is slightly larger than the types from Malaysia, it is identical in all other characters of importance, and are thus considered conspecific. Until now, *Geogarypus albus* has only been known from the type locality in Malaysia.

Olpiidae

Amblyolpium Simon

Amblyolpium bellum Chamberlin

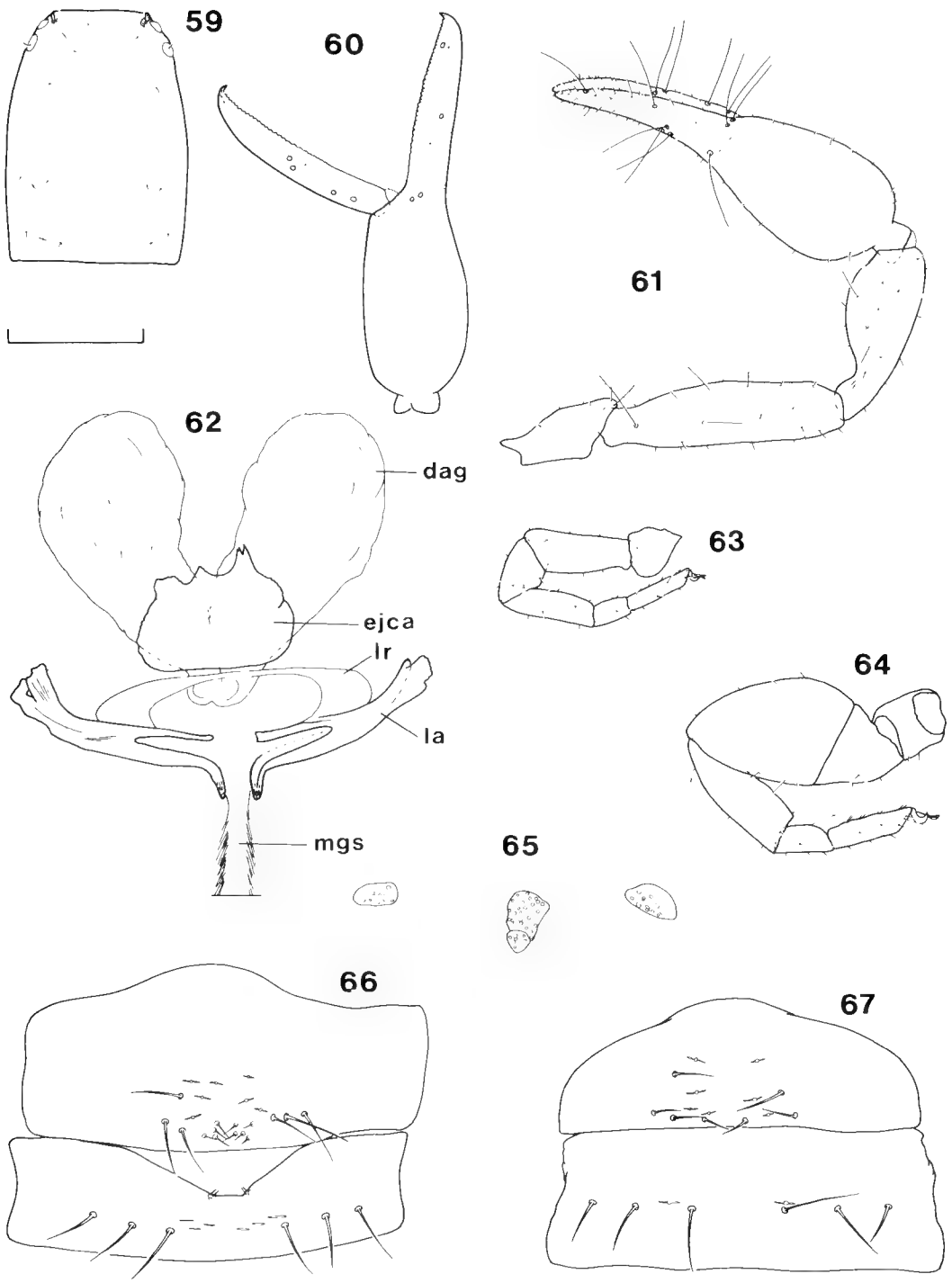
Figures 59–67

Amblyolpium bellum Chamberlin, 1930: 593–594.—Beier, 1932b: 204–205.

Type material. Holotype ♂, Banda [Kepulauan Banda, Maluku, 4°35'S, 129°55'E], Jun 1922, T. Mortensen (ZMC, JC-259.01001, SL).

Allotype ♀, Tjibodas [now Cibodas], Java, 20 Aug 1922, T.Mortensen (ZMC, JC-253.01001, SL).

Other material examined. Krakatau Islands. Rakata:



Figures 59–67. *Amblyolpium bellum* Chamberlin. Fig. 59, male, MH821.01. Figs 60, 61, 63, 64, female, MH821.06. Figs 62, 66 male, MH837.01. Fig. 65, female, MH821.04. Fig. 59, carapace, dorsal. Fig. 60, left chela, lateral. Fig. 61, right pedipalp, dorsal. Fig. 62, genitalia, ventral. Fig. 63, left leg I. Fig. 64, left leg IV. Fig. 65, genitalia, ventral. Fig. 66, genital opercula, ventral. Fig. 67, genital opercula, ventral. Scale line = 0.25 mm (figs 59–61, 63–64), 0.05 mm (fig. 62), 0.07 mm (fig. 65), 0.10 mm (figs 66–67).

Zwarte Hoek, 6°09'S, 105°25'E, under bark of *Ficus* sp., 12 Sep 1984, 3 ♂, 3 ♀ (2 ♂, 2 ♀ in NMV, remainder in MZB, 121-Y, MH821.01-06, SL); Owl Bay, 6°09'S, 105°28'E, under log, 26 Aug 1985, 1 ♂ (MZB, 227-JE, MH837.01, SL). Panjang, 6°05'S, 105°28'E: under bark of *Timonius compressicaulis*, 14 Sep 1984, 2 ♂, 3 ♀ (1 ♂, 1 ♀ in ANIC, remainder in MZB, 172-J, MH862.01-05, SP); under bark, 17 Aug 1985, 1 ♀ (MZB, 237-JE, MH868.01, SL).

Diagnosis. On the basis of the size and relative thickness of the pedipalpal segments (especially the chela), *A. bellum* most closely resembles *A. novaeguineae* Beier. On the basis of the description of the latter by Beier (1971), the two cannot be distinguished.

Description. Colour tan, carapace, pedipalps and tergites slightly darker than sternites and legs. Derm smooth. Pleural membrane longitudinally striate. Pedipalp (Fig. 61): trochanter 2.14–2.47 (♂), 2.09–2.32 (♀), femur with 2 dorsal tactile setae, 3.96–4.22 (♂), 3.40–4.41 (♀), tibia 2.29–2.64 (♂), 2.24–2.59 (♀), chela (with pedicel) 3.70–3.76 (♂), 3.31–3.82 (♀), chela (without pedicel) 3.49–3.53 (♂), 3.18–3.61 (♀), hand 1.59–1.76 (♂), 1.52–1.79 (♀) times as long as broad; hand as long as fingers. Fixed chelal finger with 8 trichobothria, moveable chelal finger with 4 trichobothria; *eb* and *esb* adjacent, *est* slightly closer to *et* than to *esb*, *ib* anterior to *esb*, *isb*, *ist* and it adjacent, *ist* slightly closer to *it* than to *isb*, *t* and *st* separated by only 2 areolar diameters (Fig. 60). Venom apparatus present in both chelal fingers; venom ducts very long, nodus ramosus near *isb* in fixed finger and basal to *st* in moveable finger. Fixed chelal finger with 33–36 (♂), 34–42 (♀) blunt marginal teeth; moveable finger with 19–22 (♂), 18–24 (♀) blunt marginal teeth. Chelicera with 5 acuminate setae on hand, *ls* and *is* the longest; serrula exterior with 17–18 (♂), 16–18 (♀) lamellae; lamina exterior of chelicera absent; flagellum of 4 blades, posterior blade slightly shorter than others, anterior blade with several spinules on anterior face; moveable finger with 1 distal seta; galea with 2 distal and 1 medial rami, not sexually dimorphic. Carapace (Fig. 59) with 4 (♂, ♀) setae on posterior margin, 1.42–1.53 (♂), 1.29–1.55 (♀) times as long as broad; 4 corneate eyes, anterior eye slightly larger than posterior eye. Tergites II–X and sternites V–X divided. Tergal chaetotaxy: ♂, 4–6: 4: 6: 6: 6–7: 6–8: 7–8: 6–8: 8–9: 10–12: 6: 2; ♀, 4–5: 4–6: 6: 6: 6: 6–8: 6–8: 7–8: 7–9: 10–12: 6–8: 2. Sternal chaetotaxy: ♂, 11–16: (1)4–6 [4] (1): (1)7–8(1): 8–9: 8–11: 8–10: 8–10: 9–12: 11–12: 6: 2; ♀, 6–10: (1)6–7(1): (1)6–8(1): 8–10: 8–11: 8–10: 8–10: 10–12: 12–15: 6–8: 2. Sternites VI and VII with a pair of slightly larger setae adjacent to midline. Coxal chaetotaxy: ♂, 8–9: 7–9: 4: 3–5; ♀, 6–9: 6–10: 4–5: 5. Male anterior genital operculum with 2 groups of small setae near posterior margin, plus several larger setae (Fig. 66). Female genital opercula (Fig. 67) not unusual. Male genitalia (Fig. 62) with incomplete lateral apodeme and complete lateral rod; dorsal anterior gland paired; median genital sac single. Female genitalia (Fig. 65) with elongate lateral cribriform plates and 2 irregularly ovoid median cribriform plates, 1 slightly smaller than the other. Spiracles with barely visible stigmatic helix. Legs (Figs 63, 64): diplotarsate; basifemur of legs I and II much longer than telofemur, junction moveable; femur IV very deep; telotarsus twice as long as basitarsus; arolium much longer than claws; claws simple; arolium divided.

Dimensions (mm), ♂ (♀): body length 1.61–2.00 (1.88–2.20); pedipalps: trochanter 0.235–0.245/0.095–0.11 (0.24–0.255/0.11–0.115), femur 0.445–0.485/0.11–0.12 (0.48–0.56/0.11–0.165), tibia 0.32–0.37/0.14–0.145 (0.36–0.415/0.14–0.185), chela (with pedicel) 0.685–0.765/0.185–0.205 (0.725–0.935/0.19–0.28), chela (without pedicel) 0.645–0.715 (0.685–0.89), moveable finger length 0.325–0.40 (0.345–0.48), hand length 0.325–0.335 (0.34–0.425); chelicera 0.155–0.18/0.085–0.10 (0.165–0.19/0.085–0.11), moveable finger length 0.115–0.125 (0.11–0.13); carapace 0.54–0.59/0.36–0.40 (0.535–0.625/0.345–0.485), anterior eye 0.04–0.045 (0.04–0.045), posterior eye 0.03–0.035 (0.03–0.04); leg I: trochanter 0.10/0.085 (0.095–0.11/0.09–0.095), basifemur 0.20–0.21/0.075–0.08 (0.205–0.225/0.08–0.085), telofemur 0.105–0.115/0.075 (0.115–0.125/0.08–0.085), tibia 0.17–0.185/0.055 (0.135–0.20/0.055–0.06), basitarsus 0.07–0.085/0.04 (0.075–0.085/0.04), telotarsus 0.125–0.14/0.03–0.035 (0.14–0.15/0.035); leg IV: trochanter 0.145–0.155/0.115 (0.165/0.12), basifemur 0.17–0.185/0.135–0.15 (0.18–0.185/0.135–0.155), telofemur 0.305–0.325/0.185–0.20 (0.305–0.345/0.18–0.215), tibia 0.26–0.28/0.095 (0.28–0.295/0.095–0.105), basitarsus 0.105–0.11/0.055 (0.105–0.12/0.055–0.06), telotarsus 0.165/0.045 (0.175–0.185/0.045–0.05).

Remarks. There is considerable variation in the size of the palpal segments in the specimens examined during this study. The holotype is slightly larger than the males from Krakatau, and the allotype is substantially larger than the females. In addition, the galea of the allotype lacks the medial ramus apparent in the remaining specimens. This suggests that the allotype may belong to a different species.

While there are several localities with the name "Banda" in Asia, Dr H. Enghoff (UZM) informed me (pers. comm.) that the holotype of this species was taken by Dr Mortensen on Kepulauan Banda in the Maluku group.

This species is known only from Kepulauan Banda, Cibodas and Krakatau.

Beierolpium Heurtault

Beierolpium oceanicum (With)

Figures 68–78

Olpium longiventer L. Koch.—Pocock, 1898: 323 (misidentification).

Garypinus oceanicus With, 1907: 77–79.—Kastner, 1927: 15.

Horus oceanicus.—Chamberlin, 1930: 600.

Xenolpium oceanicum.—Beier, 1932b: 202.—Beier, 1940: 168–169.—Beier, 1957: 16–17, fig. 6a.

Xenolpium oceanicum oceanicum.—Beier, 1957: 17.

Xenolpium oceanicum palauense Beier, 1957: 18, fig. 6b. Syn. nov.

Xenolpium oceanicum reductum Beier, 1957: 19, figs 6c, 7a–b. Syn. nov.

Xenolpium oceanicum latum Beier, 1957: 19–20, fig. 6d. Syn. nov.

Beierolpium oceanicum.—Heurtault, 1976: 67, fig. 4.

Type material. Garypinus oceanicus: lectotype ♂ (present designation), Funafuti, [W.J.] Sollas (BMNH, 1898.4.4.33, SP).

Paralectotypes: 1 ♂, 4 ♀, same data as lectotype (BMNH, 1898.4.4.34-39, SP).

Xenolpium oceanicum palauense: lectotype ♂ (present designation), Auluptagel (Aurapushekaru), Palau Islands, Sep 1952, N.L.H. Krauss (USNM, Type No. 2263, SP).

Paralectotypes: 1 ♀, same data as lectotype (USNM, 2263, SP); 1 ♀, E. Ngatpang, Babelthuap, Palau Islands, 8 Dec 1952, J.L. Gressitt (USNM, 2263, SP); 1 ♀, Agr[icultural] Exp[erimental] Station, [Colonia, Ponape], on rotten food, Gressitt (USNM, 2263, SP); 2 ♀, 1 tritonymph, Okinawa, 7 Jun 1945, A.B. Hardcastle (USNM, 2263, SP); other syntypes from South Mariana Islands and Palau Islands are apparently lodged in BPBM and FMNH (Beier 1957) but have not been examined.

Xenolpium oceanicum reductum: lectotype ♂ (present designation), Hill 541, Kusaie, 165 m, beating, 23 Mar 1953, J.F.G. Clarke (USNM, Type No. 2252, SP).

Paralectotypes: 1 ♂, 7 ♀, 1 tritonymph, same data as lectotype (USNM, 2252, SP); 3 ♀, 1 tritonymph, 3 deutonymphs, 1 protonymph, Hill 541, Kusaie, 165 m, 1 Apr 1953, J.F.G. Clarke (USNM, 2252, SP); 1 ♀, 1 deutonymph, Mutumlik, Kusaie, 22 m, 1 Mar 1953, J.F.G. Clarke (USNM, 2252, SP); 2 ♀, 1 deutonymph, 4 protonymphs, Agric. Exper. Sta., Colonia, Ponape, woody compost, 17 Jan 1953, J.L. Gressitt (USNM, 2252, SP); other syntypes from Kusaie are apparently lodged in BPBM and FMNH (Beier 1957) but have not been examined.

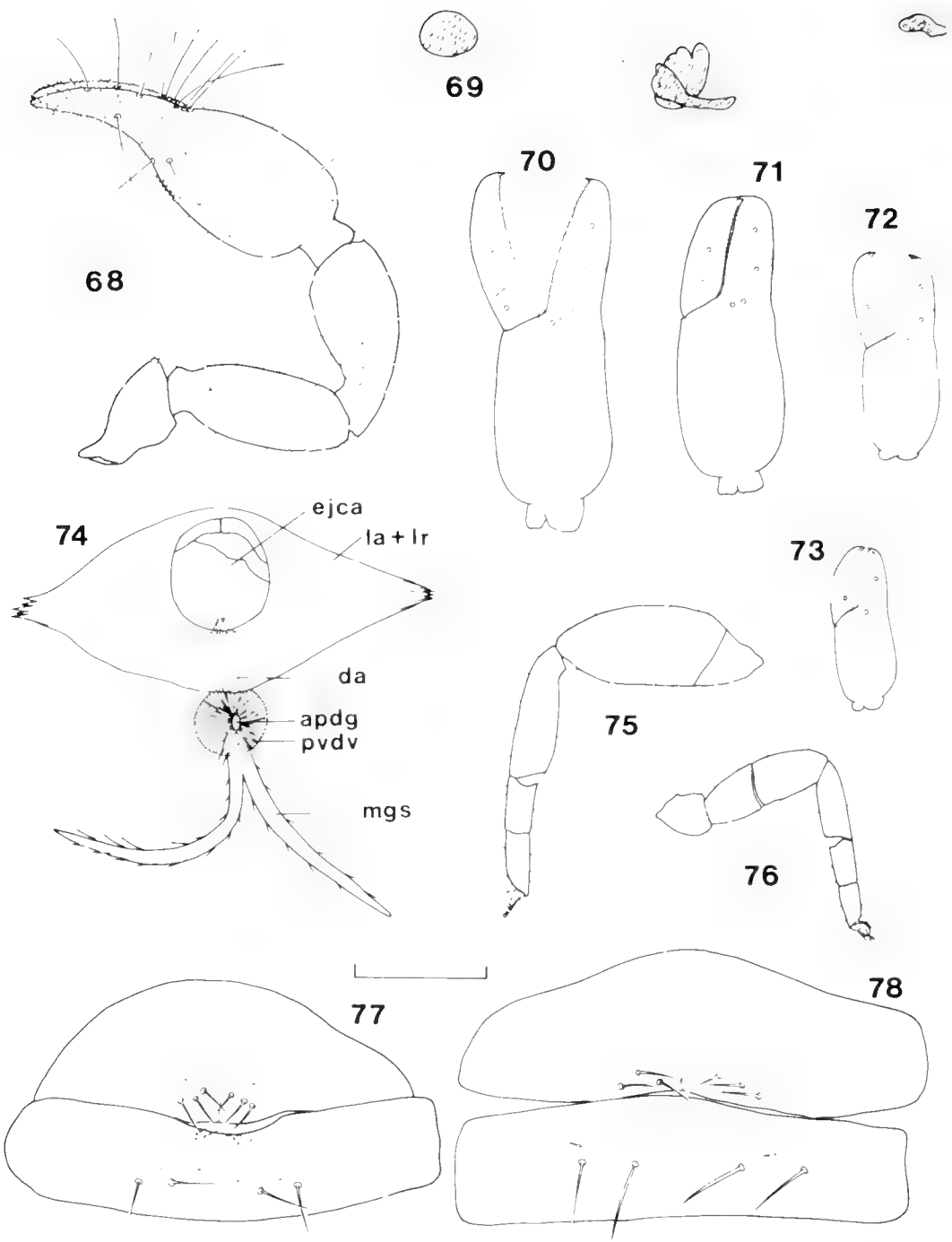
Xenolpium oceanicum latum: holotype ♀, Lwejap Island, Lae A., Marshall Islands, under rocks, dead leaves, 9 Jan 1952, F.R. Fosberg (USNM, Type No. 2265, SP).

Paratypes: 1 tritonymph, Ebeju Island, Ujae A., Marshall Islands, 8 Mar 1952, F.R. Fosberg (USNM, 2265, SP); 1 protonymph, Elluk Island, Utirik A., Marshall Islands, 2 Dec 1951, F.R. Fosberg (USNM, 2265, SP).

Other material examined. Krakatau Islands. Rakata, Zwarte Hoek, 6°09′S, 105°25′E: under bark of *Barringtonia asiatica* on beach, 15 Sep 1984, 5 ♀ (2 ♀ in ANIC, remainder in MZB, 121-AU, MH826.01-05, SL); under rocks in bat cave, 15 Sep 1984, 1 tritonymph (MZB, 121-AS, MH825.01, SL). Sertung, spit, 6°04′S, 105°24′–25′E, *Casuarina equisetifolia* litter, 11 Sep 1984, 2 tritonymphs, 2 deutonymphs, 1 protonymph (MZB, 151-D, MH851.06-10, SL). Anak Krakatau, 6°06′S, 105°26′S, litter, 10 Sep 1984, 1 ♂, 1 tritonymph (MZB, 109-M, MH870.01-02, SL); litter of alang alang [*Imperata cylindrica* (L.) Beauv.], Aug 1985, 2 ♂, 2 ♀, 3 tritonymphs, 3 deutonymphs, 1 protonymph (1 ♂, 1 deutonymph in MZB, remainder in NMV, 216-AG, MH872.01-11, SL). Java, Ujung Kulon, Pulau Peucang, 6°45′S, 105°15′E, beating *Pandanus* sp., 19 Sep 1984, 1 ♀ (MZB, 179-Y, MH812.02, SL).

Diagnosis. Beierolpium oceanicum is smaller than *B. holmi* Mahnert, *B. kerioense* Mahnert, *B. lawrencei* (Beier) and *B. rossi* (Beier), and is larger than *B. clarum* (Beier). It most closely resembles *B. benoiti* Mahnert, from which it differs by its stouter chela, and *B. tanense* Mahnert, from which it differs by the more rounded chelal hand.

Description. Adults: pedipalps, tergites III–XI and most of carapace dark yellow-brown, tergites I–II and posterior portion of carapace white, sternites and legs slightly lighter. Derm smooth except for several small denticles on interior margin of chelal hand near base of fingers. Pleural membrane longitudinally striate. Pedipalp (Fig. 68): trochanter 1.68–1.96 (♂), 1.72–1.88 (♀), femur with two dorsal tactile setae, 2.44–2.78 (♂), 2.19–3.04 (♀), tibia 2.19–2.41 (♂), 1.97–2.56 (♀), chela (with pedicel) 2.82–3.02 (♂), 2.73–2.98 (♀), chela (without pedicel) 2.62–2.78 (♂), 2.50–2.72 (♀), hand 1.39–1.50 (♂), 1.35–1.47 (♀) times as long as broad. Fixed chelal finger with 8 trichobothria, moveable chelal finger with 4 trichobothria; *eb*, *esb* and *isb* in straight line at base of fingers, *est* closer to *isb* than to *et*, *ib* and *ist* adjacent, basal, *it* anterior to *est*; *b*, *sb* and *st* basal, *sb* and *st* adjacent (Fig. 70). Venom apparatus present in both chelal fingers; venom ducts short, nodus ramosus distal. Fixed chelal finger with 24 (♂), 27–28 (♀) flattened marginal teeth; moveable finger with 26 (♂), 27–31 (♀) marginal teeth. Chelicera with 5 acuminate setae on hand, *bs* shorter than others; serrula exterior with 18 (♂, ♀) lamellae; lamina exterior of chelicera present; flagellum of 3 blades,



Figures 68–78. *Beierolpium oceanicum* (With). Figs 68–70, 75, 76, 78, female, MH826.02. Fig. 71, tritonymph, MH825.01. Fig. 72, deutonymph, MH872.08. Fig. 73, protonymph, MH872.11. Figs 74, 77, male, MH872.02. Fig. 68, right pedipalp, dorsal. Fig. 69, genitalia, ventral. Fig. 70, left chela, lateral. Fig. 71, left chela, lateral. Fig. 72, left chela, lateral. Fig. 73, left chela, lateral. Fig. 74, genitalia, ventral. Fig. 75, left leg IV (without trochanter). Fig. 76, left leg I. Fig. 77, genital opercula. Fig. 78, genital opercula. Scale line = 0.25 mm (figs 68, 70–73, 75–76), 0.10 mm (figs 69, 77–78), 0.05 mm (fig. 74).

anterior blade longer and stouter than others, without spinules; moveable finger with 1 distal seta; galea of male simple, without rami, of female long with 3 distal rami. Carapace with 6–8 setae on median section, 2 setae on posterior margin, 1.17–1.30 (♂), 0.98–1.13 (♀) times as long as broad; 4 corneate eyes, anterior eye slightly larger than posterior eye. Tergites and sternites not divided. Tergal chaetotaxy: ♂, 2: 2–4: 4: 4: 4: 4: 4–6: 5–7: 6–7: 4–6: 6–7: 2; ♀, 2: 2–4: 3–5: 4: 4: 4–5: 4–6: 4–6: 5–7: 6–7: 7–8: 2. Sternal chaetotaxy: ♂, 6–7: (0)3–4 [1–6] (0): (0)4(0): 5–6: 4: 4: 4–5: 6: 6: 7–8: 2; ♀, 5–9: (0)4(0): (0)4–5(0): 4–6: 4: 4–5: 4: 6: 6: 7: 2. Coxal chaetotaxy: ♂, 4: 3–5: 5–6: 6–7; ♀, 4–6: 4–8: 6–11: 9–13. Genital opercula (Figs 77, 78) not unusual. Male genitalia (Fig. 74) with lateral apodeme and lateral rod fused into broad plate with large central hole; dorsal apodeme posteriorly directed; posterior ventral diverticulum circular; median genital sac bifid. Female genitalia (Fig. 69) with small lateral cribriform plates and 2 median cribriform plates. Spiracles with stigmatic helix. Legs (Figs 75, 76): diplotarsate; basifemur and telofemur of legs I and II subequal; arolium longer than claws; claws simple; arolium undivided.

Dimensions (mm), ♂ (♀): body length 1.27–1.54 (1.59–1.95); pedipalps: trochanter 0.21–0.245/0.115–0.13 (0.235–0.275/0.13–0.16), femur 0.33–0.375/0.13–0.14 (0.34–0.455/0.13–0.18), tibia 0.34–0.385/0.155–0.165 (0.345–0.455/0.16–0.20), chela (with pedicel) 0.62–0.68/0.205–0.23 (0.655–0.78/0.235–0.275), chela (without pedicel) 0.56–0.62 (0.60–0.72), moveable finger length 0.275–0.335 (0.28–0.34), hand length 0.285–0.315 (0.325–0.365); chelicera 0.145–0.17/0.095 (0.195–0.215/0.10–0.12), moveable finger length 0.12–0.13 (0.135–0.14); carapace 0.455–0.51/0.35–0.39 (0.445–0.565/0.375–0.50), anterior eye 0.06 (0.055–0.07), posterior eye 0.03–0.04 (0.035–0.045); leg I: trochanter 0.085–0.095/0.075–0.08 (0.095–0.11/0.085–0.095), basifemur 0.095–0.125/0.08–0.085 (0.135–0.175/0.09–0.10), telofemur 0.135–0.145/0.085 (0.145–0.175/0.09–0.105), tibia 0.155–0.165/0.06 (0.18–0.20/0.06–0.07), basitarsus 0.09–0.115/0.045–0.05 (0.085–0.095/0.045–0.05), telotarsus 0.08–0.09/0.035–0.04 (0.09–0.11/0.04–0.045); leg IV: trochanter 0.13–0.155/0.10–0.105 (0.16–0.19/0.105–0.14), basifemur 0.125–0.13/0.095–0.10 (0.13–0.165/0.10–0.12), telofemur 0.26–0.32/0.145–0.16 (0.34–0.395/0.16–0.19), tibia 0.25–0.26/0.075–0.085 (0.275–0.325/0.08–0.10), basitarsus 0.10–0.11/0.05–0.055 (0.11–0.135/0.055–0.065), telotarsus 0.12–0.13/0.045–0.05 (0.13–0.15/0.05–0.055).

Tritonymphs: colour paler than adults. Pedipalp: trochanter 1.73–1.80, femur 2.15–2.29, tibia 1.93–2.17, chela (with pedicel) 2.76–2.94, chela (without pedicel) 2.61–2.69, hand 1.32–1.45 times as long as broad. Fixed chelal finger with 7 trichobothria, moveable chelal finger with 3 trichobothria (Fig. 71); *isb* and *sb* absent. Serrula exterior of chelicera with 16–17 lamellae; galea as in female. Carapace with 8–9 setae on medial section, with 2 setae on posterior margin; 0.94–1.41 times as long as broad. Tergal chaetotaxy: 2–3: 4: 4: 4: 4: 4: 4: 4–5: 6: 6: 6: 2. Sternal chaetotaxy: 0: (0)4(0): (1)2(1): 6: 4: 4: 4–5: 4–6: 6: 5–7: 2. Coxal chaetotaxy: 4: 4: 3–4: 4–7. Diplotarsate.

Dimensions (mm): body length 1.45–1.84; pedipalps: trochanter 0.18–0.21/0.10–0.12, femur 0.26–0.32/0.115–0.14, tibia 0.27–0.315/ 0.14–0.16, chela (with pedicel) 0.525–0.61/0.18–0.21, chela (without pedicel) 0.48–0.565, moveable finger length 0.245–0.265, hand length 0.25–0.305; carapace 0.38–0.405/0.32–0.405.

Deutonymphs: colour paler than adults. Pedipalp: trochanter 1.56–1.72, femur 2.47–2.61, tibia 1.83–2.00, chela (with pedicel) 2.81–2.97, chela (without pedicel) 2.56–2.69, hand 1.31–1.38 times as long as broad. Fixed chelal finger with 6 trichobothria, moveable chelal finger with 2 trichobothria (Fig. 72); *esb*, *isb*, *sb* and *st* absent. Serrula exterior of chelicera with 14–15 lamellae; galea as in female. Carapace with 7–8 setae on medial section and 2 setae on posterior margin; 0.86–0.94 times as long as broad. Tergal chaetotaxy: 2: 2–3: 2: 4: 4: 4: 4: 4: 4–5: 4–5: 4–5: 2. Sternal chaetotaxy: 0: (0)2(0): (1)2(1): 3–4: 2: 2: 2–3: 4–6: 6: 7: 2. Coxal chaetotaxy: 3: 2: 2: 2. Diplotarsate.

Dimensions (mm): body length 0.97–1.18; pedipalps: trochanter 0.14–0.155/0.085–0.09, femur 0.225–0.235/0.09–0.095, tibia 0.22–0.23/0.11–0.12, chela (with pedicel) 0.415–0.45/0.145–0.16, chela (without pedicel) 0.38–0.41, moveable finger length 0.185–0.22, hand length 0.20–0.21; carapace 0.28–0.32/0.305–0.37.

Protonymphs: colour paler than adults. Pedipalp: trochanter 1.79, femur 1.44, tibia 1.83, chela (with pedicel) 2.83, chela (without pedicel) 2.58, hand 1.29 times as long as broad. Fixed chelal finger with 3 trichobothria, moveable chelal finger with 1 trichobothrium (Fig. 73); *eb*, *et*, *ist* and *t* present. Serrula exterior of chelicera with 11 lamellae; galea as in female. Carapace with 4 setae on medial section and 2 setae on posterior margin; 1.00 times as long as broad. Tergal chaetotaxy: 2: 2: 2: 2: 2: 2: 2: 2: 4: 4: 4: 2. Sternal chaetotaxy: 0: (0)2(0): (1)2–4(1): 2–4: 2: 2: 2: 2: 2: 4: 2. Coxal

chaetotaxy: 1: 1: 1: 1. Diplotarsate.

Dimensions (mm): body length 0.89–0.99; pedipalps: trochanter 0.125/0.07, femur 0.18/0.08, tibia 0.165/0.09, chela (with pedicel) 0.34/0.12, chela (without pedicel) 0.31, moveable finger length 0.155, hand length 0.155; carapace 0.28/0.28.

Remarks. Beier (1957) utilized the shape of the carapace and the number of carapacal setae to divide this species into four subspecies. I have examined much of his original material, including the primary types, as well as additional material from Krakatau and do not agree with his conclusions. The shape of the carapace is more variable than he stated, even within populations, and the number of carapacal setae varies. Indeed, even within the type series of *X. oceanicum reductum* there is considerable variation in the number of setae in the median area, including bilateral variation in individual specimens, as demonstrated for *Beierolpium benoiti* Mahnert by Mahnert (1978, fig. 1). Thus, all of the subspecies described by Beier (1957) are here synonymized with *B. oceanicum*.

Holotypes were not designated for *Garypinus oceanicus*, *Xenolpium oceanicum palauense* and *X. oceanicum reductum* by their authors, and lectotypes have been nominated herein accordingly. With (1907) stated that five males and six females were present in the type collection of *G. oceanicus*, but only two males and four females were present in the BMNH collections (Mr P. D. Hillyard, pers. comm.).

This species is widely distributed in the Asian region from Samoa in the east to Krakatau in the west.

Withiidae

Metawithius Chamberlin

Metawithius yurii (Redikorzev)

Figures 79–85

Microwithius yurii Redikorzev, 1938: 106–108, figs 35–38.–Beier, 1951: 104.

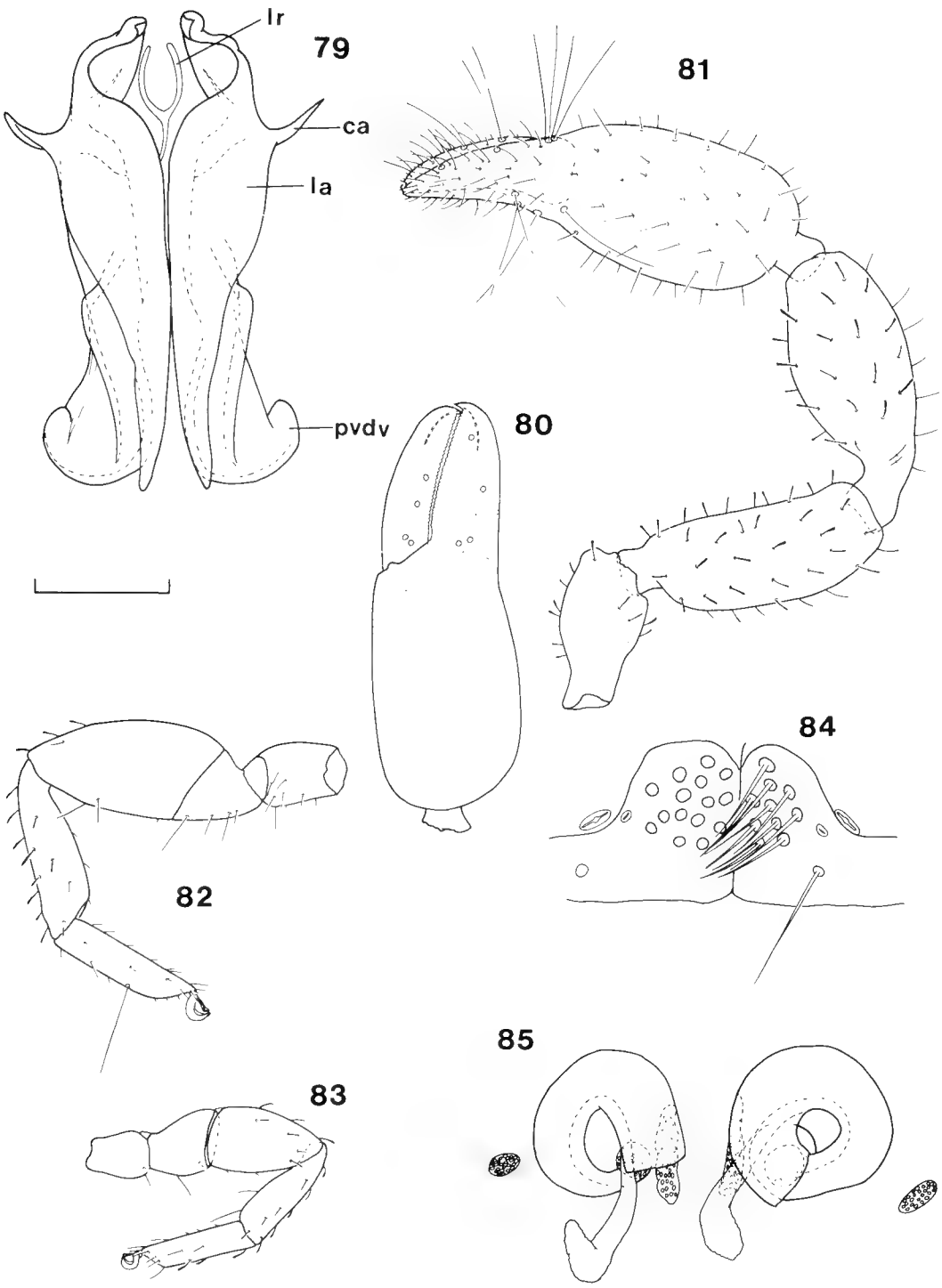
Metawithius (Microwithius) yurii (Redikorzev). – Beier, 1954: 45.

Type material. Syntypes: 1 ♂, Duong-Dong, Ile Phu-Quoc [Dao Phú Quoc], Kampuchea, Feb 1930, C. Dawydoff (MNHN); 1 ♂, same data except 25 Nov 1931 depository unknown, not examined); 2 ♂, archipel Poulo-Condore, Vietnam, 10 Apr 1931, C. Dawydoff (depository unknown, not examined).

Other material examined. Krakatau Islands. Rakata, south face, 6°10′S, 105°26′E, 20–50 m, beating, 25 Aug 1985, 1 ♂ (ANIC, 224-GM, MH841.01, SL). Sertung, 6°05′S, 105°23′E: under bark of dead *Ficus* sp. on beach, 11 Sep 1984, 1 ♂ (MZB, 151-R, MH853.01, SL); ridge, beating in rainforest, 11 Sep 1984, 1 ♂, 1 ♀ (MZB, 151-AD, MH852.01-02, SL); east ridge, beating in rainforest, 19 Aug 1985, 1 ♂ (NMV, 244-EJ, MH873.01, SL).

Diagnosis. Males of this species are very similar to three other species traditionally placed in the subgenus *Microwithius* Redikorzev based on the possession of setal patches on sternites VII–XI: *M. indicus* Murthy and Ananthakrishnan (India), *M. chamundiensis* Sivaraman (India) and *M. bulli* Sivaraman (India). Unfortunately, the genitalia of these species have yet to be described and thus comparisons with *M. yurii* cannot be made.

Description. Colour: pedipalps, carapace and tergites red-brown. Surfaces of carapace, tergites and trochanter, femur and tibia of pedipalps coarsely granulate; those of chela and sternites smooth. Pleural membrane longitudinally striate, wrinkled. Pedipalp (Fig. 81): trochanter 1.42–1.94 (♂), 1.79 (♀), femur 2.63–2.84 (♂), 2.78 (♀), tibia 2.34–2.66 (♂), 2.45 (♀), chela (with pedicel) 3.02–3.10 (♂), ? (♀), chela (without pedicel) 2.79–2.88 (♂), ? (♀), hand 1.63–1.73 (♂), ? (♀) times as long as broad. Fixed chelal finger with 8 trichobothria, moveable chelal finger with 4 trichobothria; *eb*, *esb* adjacent, basal, *est* midway between *esb* and *et*, *ib*, *isb*, *ist* and *it* grouped together basally, *b* and *sb* adjacent, *st* slightly closer to *t* than to *sb* (Fig. 80). Venom apparatus present in both chelal fingers; nodus ramosus near *et* in fixed finger and between *t* and tip of finger in moveable finger. Fixed finger with 26–28 (♂), 28 (♀) marginal teeth, moveable finger with 28–30 (♂), 31 (♀) marginal teeth, accessory teeth absent. Chelicera with 5 setae on hand, *bs* and *sbs* denticulate, remainder acuminate; serrula exterior with 17–18 (♂), ? (♀) lamellae; flagellum of 4 blades, anterior blade with 4–5 spinules on anterior face, remainder smooth; galea long, with 6 distal to subdistal rami. Carapace with 6–8 (♂), 5 (♀) setae on posterior margin; 1.21–1.28 (♂), 1.26 (♀) times as long as broad, widest medially; 1 pair of eye spots present; median furrow present. Tergites II–IX and sternites V–X divided. Tergal chaetotaxy: ♂, 8–9: 9: 9–10: 10–11: 10–12: 11–12: 10–12: 10–13: 10–11: 9–10: 7–8: 2; ♀, 9: 9: 9: 14: 12: 14: 11: 13: 10: 11: 8: 2. Sternal chaetotaxy: ♂, 4: (1)6–9(1): (2)9–10(2): 15–17: 14–15: 10–12[12–14/11–17]: 10–13[14–15/12–20]: 11[10–13/12–15]: 12–13: 9–11: 2; ♀, 0: 9: (1)8(1): (2)11(2): 16: 14: 14: 16: 17: 12: 12: 2. Sternites VII–IX of male with paired median sense patches (Fig. 84). Coxal chaetotaxy: ♂, 6–7: 7: 7–8: 11–12;



Figures 79–85. *Metawithius yurii* (Redikorzev). Figs 79–81, 84, male, MH853.01. Figs 82–83, 85, female, MH852.02. Fig. 79, genitalia, ventral. Fig. 80, left chela, lateral. Fig. 81, right pedipalp, dorsal. Fig. 82, left leg IV. Fig. 83, left leg I. Fig. 84, setal patches on sternite IX (setae on right half omitted), ventral. Fig. 85, spermathecae. Scale line = 0.14 mm (figs 79, 85), 0.25 mm (figs 81–83), 0.07 mm (fig. 84).

♀, 7: 7: 5: 13. Genital opercula not unusual. Male genitalia (Fig. 79): lateral rod Y-shaped; lateral apodeme elongate, with lateral chitinised arch; posterior diverticulum of dorsal diverticulum rounded. Female genitalia (Fig. 85) with coiled spermathecae; glandular strip adjacent to, and lying over, spermathecae; median cribriform plates long and elongate, lateral cribriform plates ovoid. Spiracles with stigmatic helix. Legs (Figs 82, 83): monotarsate; junction of basifemur and telofemur of leg I slightly oblique; tarsus IV with median tactile seta, TS = 0.54–0.60 (♂), 0.51 (♀); subterminal tarsal seta simple, curved; arolium slightly shorter than claws; claws simple.

Dimensions (mm), ♂ (♀): body length 1.70–2.08 (2.39); pedipalps: trochanter 0.27–0.32/0.155–0.19 (0.295/0.165), femur 0.505–0.57/0.18–0.215 (0.555/0.20), tibia 0.50–0.55/0.205–0.235 (0.54/0.22), chela (with pedicel) 0.79–0.86/0.255–0.28 (0.875/?), chela (without pedicel) 0.735–0.795 (0.81), moveable finger length 0.32–0.37 (0.35), hand length 0.44 0.48 (0.47); chelicera 0.165–0.21/ 0.105–0.11 (0.145/0.11), moveable finger length 0.14–0.16 (0.16); carapace 0.56–0.655/0.455–0.515 (0.66/0.525); leg I: trochanter 0.125–0.135/0.095–0.105, (0.13/0.095), basifemur 0.115–0.135/ 0.135–0.145 (0.135–0.135), telofemur 0.225–0.265/0.135–0.145 (0.255/0.135), tibia 0.22–0.255/0.085–0.09 (0.235/0.075), tarsus 0.195–0.225/0.055–0.065 (0.22/0.055); leg IV: trochanter 0.205–0.21/ 0.105–0.13 (0.225/0.115), basifemur 0.165–0.175/0.125–0.14 (0.19/0.13), telofemur 0.35–0.39/0.175–0.20 (0.385/0.195), tibia 0.33–0.36/0.095–0.105 (0.365/0.10), tarsus 0.27–0.28/0.065–0.07 (0.345/0.07), distance of tarsal tactile seta from proximal margin 0.145–0.165 (0.175).

Remarks. The coiled spermathecae of *M. yurii* are the first such spermathecae to be recorded in the Withiidae, but the genitalia of most withiid species have not been described.

I have examined the syntypes of *Metawithius murrayi* (Pocock), the type species of the genus, (one male and one female, BMNH, 1898.10.14.7-9), but the internal genitalia were not examined in detail. It is apparent that these specimens are not conspecific with the material recorded by With (1906) from the Nicobars.

Atemnidae

Paratemnus Beier

Paratemnus assimilis Beier

Figures 86–95

Chelifer birmanicus Thorell: Tullgren, 1912: 267 (misidentification).

Paratemnus assimilis Beier, 1932a: 569–570, fig. 9. – Beier, 1932c: 40.

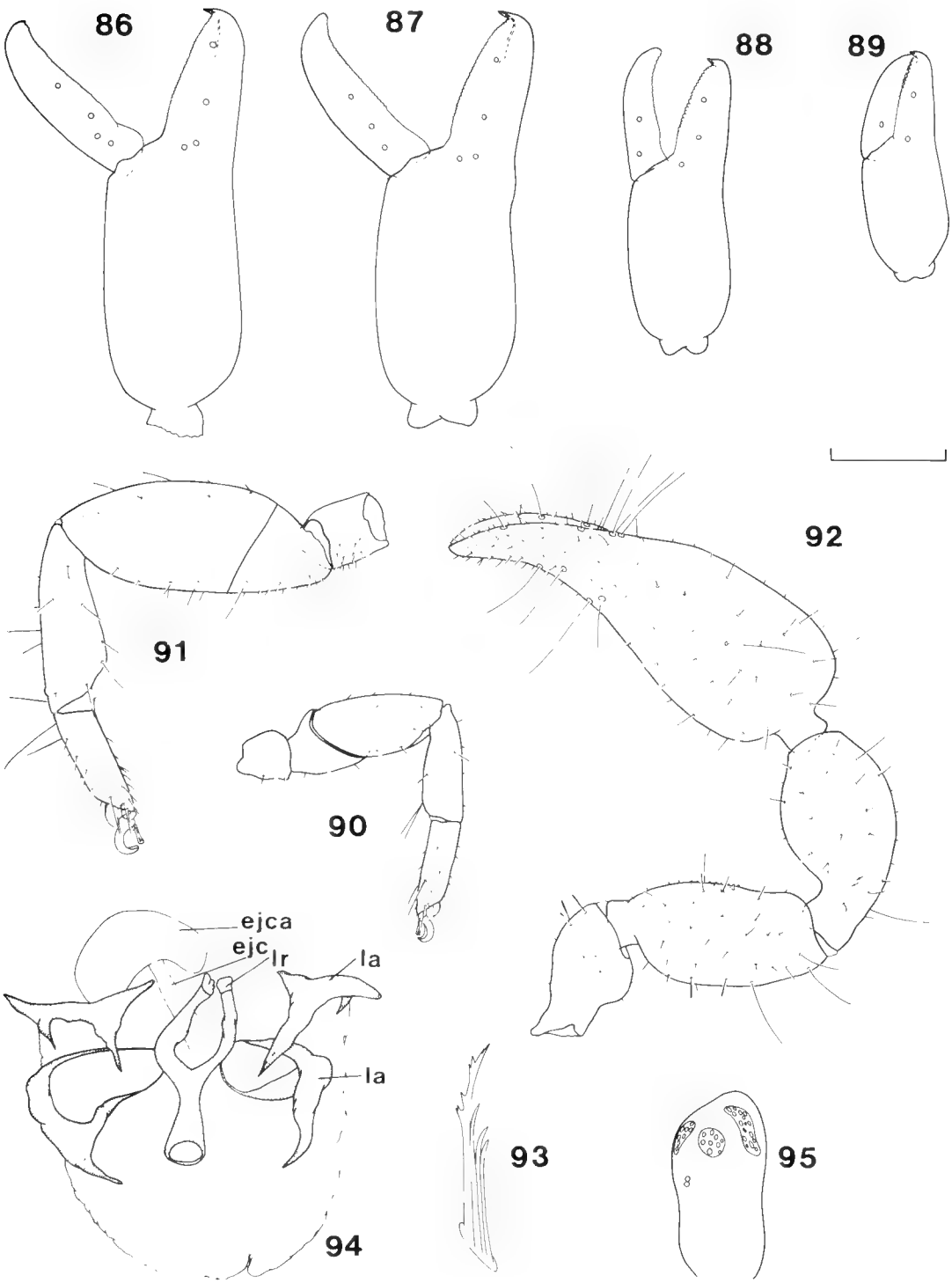
Type material. Lectotype ♂ (present designation), Kolambugan, North Mindanao, Philippines, 27 Jan 1915, Bottcher (ZMB, 28430, SP).

Paralectotypes: 3 ♀, same data as lectotype (ZMB, 28430, SP); 1 ♂, 1 ♀, Mommangan, North Mindanao, Philippines, 22 Feb 1915, Bottcher (ZMB, 28432, SP); 1 ♀, Insel Basilan, 11 Dec 1914, Bottcher (ZMB, 28431, SP).

Other material examined. Krakatau Islands. Rakata: Zwarte Hoek, 6°09'S, 105°25'E, in tent, 13 Sep 1984, 1 ♀ (MZB, 121-L, MH822.01, SL); south ridge, 6°10'S, 105°26'E, 100 m, beating, 4 Sep 1984, 1 ♀ (NMV, 178-A, MH838.01, SL); 850 ft (259 m), litter, 19 Sep 1984, 1 tritonymph, 2 protonymphs (MZB, 40-8, MH846.01-03, SL). "Krakatau", May 1908, 7 ♀, 4 tritonymphs, 1 deutonymph (RMNH, SP). Java, 2 km E of Carita, 6°16'S, 105°50'E, under bark of dead tree, rainforest, 26 Aug 1984, 3 ♂, 8 ♀, 3 tritonymphs, 1 deutonymph, 1 protonymph (1 ♂, 3 ♀, 2 tritonymphs, 1 protonymph in NMV, 2 ♀ in ANIC, remainder in MZB, 115-H, MH805.01-16, SL and SP).

Diagnosis. The only other described species of the genus *Paratemnus* with minute denticles on the anterior margin of the pedipalpal femur, but with the other pedipalpal segments smooth or virtually so, is *P. ceylonicus* Beier, from which *P. assimilis* differs by the slightly thinner leg segments [e.g. tibia IV 2.95–2.98 (♂), 2.85–3.19 (♀) times as long as broad].

Description. Adults: pedipalps dark red-brown, carapace, legs and tergites lighter, carapace and tergites of similar colouration. Derm of pedipalps, carapace and tergites fairly smooth, except for anterior face of pedipalpal femur and, to a lesser extent, tibia which possess minute denticles. Pedipalp (Fig. 92): trochanter 1.70–1.76 (♂), 1.69–1.80 (♀), femur pedicellate 2.10–2.30 (♂), 2.22–2.38 (♀), tibia pedicellate 1.82–1.89 (♂), 1.86–2.00 (♀), chela (with pedicel) 2.66–2.70 (♂), 2.58–2.87 (♀), chela (without pedicel) 2.56–2.60 (♂), 2.45–2.70 (♀), hand 1.43–1.51 (♂), 1.40–1.61 (♀) times as long as broad. Fixed chelal finger with 8 trichobothria, moveable chelal finger with 4 trichobothria; *eb* and *esb* adjacent, *est* slightly closer to *esb* than to *et*, *ib* and *isb* adjacent, *ist* and *it* adjacent, medial, *b* and *sb* adjacent, *st* closer to *sb* than to *t* (Fig. 86) (*ist* of 1 female on left chela near *isb* and *ib*). Venom apparatus present in fixed chelal finger terminating in nodus ramosus proximal to *et*. Fixed finger with 36 (♂), 34–38 (♀) marginal teeth, without accessory teeth; moveable finger with 46–47 (♂), 39–48 (♀) marginal teeth,



Figures 86–95. *Paratemnus assimilis* Beier. Figs 86, 92, female, MH805.09. Fig. 87, tritonymph, MH805.12. Fig. 88, deutonymph, MH805.15. Fig. 89, protonymph, MH805.16. Figs 90, 91, 93, 94, male, MH805.01. Fig. 95, female, MH822.01. Fig. 86, left chela, lateral. Fig. 87, left chela, lateral. Fig. 88, left chela, lateral. Fig. 89, left chela, lateral. Fig. 90, left leg I. Fig. 91, left leg IV. Fig. 92, right pedipalp, dorsal. Fig. 93, flagellum. Fig. 94, genitalia, ventral. Fig. 95 Spermatheca, ventral. Scale line = 0.35 mm (figs 86, 90–92), 0.25 mm (figs 87–89), 0.07 mm (figs 93–95).

without accessory teeth. Chelicera with 4 setae on hand, *sbs* absent, *bs* and *es* denticulate; serrula exterior of 21–22 (♂), 20–23 (♀) lamellae; flagellum of 4 blades, anterior blade with several spinules on anterior face (Fig. 93); galea of male with 4 distal to subdistal rami, of female with 4 distal and 2 medial rami. Carapace with 6–7 (♂), 6–9 (♀) setae on posterior margin, 1.09–1.18 (♂), 0.98–1.26 (♀) times as long as broad; 2 eye spots present; without furrows. Tergites V–X and sternites V–X with very faint division. Tergal chaetotaxy: ♂, 8: 7–8: 7–8: 10–11: 11–13: 11–13: 11–12: 11–14: 11–12: 12–13: 12: 2; ♀, 8–10: 7–10: 8–11: 9–11: 11–14: 10–15: 12–15: 10–15: 11–15: 13–16: 10–14: 2. Sternal chaetotaxy: ♂, 16–18: (3)6–7[0](3): (1)7–8(1): 14–15: 13: 12–14: 13: 13–14: 14: 10: 2; ♀, 9–15: (2–3)6–8(2–3): (1)7–9(1–2): 12–16: 13–16: 13–16: 14–16: 14–16: 14–16: 11–14: 2. Coxal chaetotaxy: ♂, 10–11: 9: 6–9: 17–18; ♀, 8–12: 6–11: 6–11: 14–19. Genital opercula not unusual. Male genitalia (Fig. 94): lateral rod Y-shaped; ejaculatory atrium moderately large. Female spermathecae of 1 receptaculum, with several cribriform plates externally (Fig. 95). Legs (Figs 90, 91): monotarsate; femoral junction of legs I and II oblique; tibia IV 2.95–2.98 (♂), 2.85–3.19 (♀) times as long as broad; subterminal tarsal seta simple, curved; leg IV with one tactile seta basally on tarsus; claws simple; arolium slightly shorter than claws.

Dimensions (mm), ♂ (♀): body length 2.81–3.67 (2.69–4.05); pedipalps: trochanter 0.45–0.475/0.255–0.275 (0.395–0.475/0.225–0.27), femur 0.715–0.805/0.33–0.35 (0.62–0.795/0.27–0.345), tibia 0.69–0.755/0.38–0.40 (0.59–0.745/0.31–0.38), chela (with pedicel) 1.30–1.405/0.485–0.52 (1.13–1.40/0.40–0.52), chela (without pedicel) 1.255–1.34 (1.075–1.335), moveable finger length 0.555–0.62 (0.47–0.625), hand length 0.73–0.765 (0.62–0.775); chelicera 0.345–0.36/0.17–0.195, (0.315–0.375/0.155–0.19), moveable finger length 0.265–0.29 (0.23–0.30); carapace 0.905–0.985/0.765–0.87 (0.81–0.92/0.685–0.94); leg I: trochanter 0.18/0.145 (0.16–0.18/0.135–0.16), basifemur 0.245–0.26/0.205–0.21 (0.23–0.27/0.185–0.215), telofemur 0.42–0.425/0.19–0.20 (0.365–0.43/0.165–0.205), tibia 0.39–0.40/0.13–0.135 (0.34–0.395/0.11–0.14), tarsus 0.32–0.325/0.095–0.10 (0.305–0.34/0.075–0.10); leg IV: trochanter 0.275–0.295/0.205–0.21 (0.285–0.315/0.185–0.215), basifemur 0.335–0.38/0.25–0.255 (0.305–0.36/0.22–0.26), telofemur 0.69–0.70/0.345–0.355 (0.58–0.715/0.28–0.35), tibia 0.59–0.605/0.20–0.205 (0.525–0.61/0.175–0.205), tarsus 0.415–0.42/0.13–0.135 (0.365–0.43/0.10–0.13).

Tritonymphs; colour pale. Pedipalp: trochanter 1.66–1.70, femur 2.30–3.00, tibia 1.87–2.08, chela (with pedicel) 2.78–2.95, chela (without pedicel) 2.65–2.83, hand 1.55–1.65 times as long as broad; hand longer than fingers. Fixed chelal finger with 7 trichobothria, moveable chelal finger with 3 trichobothria; *ist* and *sb* absent (Fig. 87). Chelicera with 4 setae on hand; serrula exterior with 16–20 lamellae; moveable finger with 1 seta; galea long with 3–5 distal to subdistal rami. Carapace with 6–7 setae on posterior margin; 1.06–1.20 times as long as broad. Tergal chaetotaxy: 6–8: 6: 6–7: 7–8: 9–11: 6–10: 9–11: 8–11: 8–10: 10–14: 8–11: 2. Sternal chaetotaxy: 2–5: (2–3)5–6(2–3): (1)5–6(1): 10–12: 7–11: 9–10: 10–11: 9–11: 10–13: 8–11: 2. Coxal chaetotaxy: 6–8: 4–7: 4–6: 8–12. Monotarsate.

Dimensions (mm): body length 2.42–2.96; pedipalps: trochanter 0.315–0.34/0.19–0.20, femur 0.505–0.63/0.21–0.225, tibia 0.47–0.54/0.245–0.26, chela (with pedicel) 0.93–0.965/0.315–0.34, chela (without pedicel) 0.89–0.92, moveable finger length 0.375–0.445, hand length 0.505–0.55; carapace 0.66–0.75/0.55–0.66.

Deutonymph: colour pale. Pedipalps: trochanter 1.81, femur 2.23, tibia 1.88, chela (with pedicel) 2.83, chela (without pedicel) 2.76, hand 1.46 times as long as broad; hand longer than fingers. Fixed chelal finger with 6 trichobothria, moveable chelal finger with 2 trichobothria; *esb*, *ist*, *sb* and *st* absent (Fig. 88). Chelicera with 4 setae on hand; serrula exterior with 17 lamellae; moveable finger with 1 seta; galea long with 3 distal to subdistal rami. Carapace with 6 setae on posterior margin; 1.11 times as long as broad. Tergal chaetotaxy: 6: 6: 6: 6: 6: 6: 7: 6: 6: 8: 8: 2. Sternal chaetotaxy: 1: (1)4(1): (1)4(1): 8: 7: 8: 7: 6: 8: 8: 2. Coxal chaetotaxy: 4: 4: 3: 6. Monotarsate.

Dimensions (mm): body length 2.29; pedipalps: trochanter 0.235/0.13, femur 0.335/0.15, tibia 0.32/0.17, chela (with pedicel) 0.65/0.23, chela (without pedicel) 0.635, moveable finger length 0.315, hand length 0.335; carapace 0.63/0.57.

Protonymphs: colour very pale. Pedipalps: trochanter 1.58–1.70, femur 1.91–2.33, tibia 1.68–1.93, chela (with pedicel) 2.83–3.00, chela (without pedicel) 2.69–2.83, hand 1.47–1.64 times as long as broad; hand longer than finger. Fixed chelal finger with 3 trichobothria, moveable chelal finger with 1 trichobothrium; *eb*, *et*, *ib* and *t* present (Fig. 89). Chelicera with 4 setae on hand; serrula exterior with 14–15 lamellae; moveable finger without seta; galea long with 3 distal rami. Carapace with 4–5 setae on posterior margin; 0.79–1.01 times as long as broad. Tergal

chaetotaxy: 4: 4: 4: 4: 4–5: 4–5: 4–5: 4: 4: 4: 4: 2. Sternal chaetotaxy: 0: (0)2(0): (1)2(1): 4: 4: 4: 4: 4: 2. Coxal chaetotaxy: 2: 2: 2: 2. Monotarsate.

Dimensions (mm): body length 1.41–1.55; pedipalps: trochanter 0.18–0.195/0.115–0.12, femur 0.23–0.28/0.12, tibia 0.235–0.27/0.135–0.145, chela (with pedicel) 0.51–0.54/0.18, chela (without pedicel) 0.485–0.51, moveable finger length 0.225–0.26, hand length 0.265–0.295; carapace 0.435–0.465/0.43–0.55.

Remarks. Beier (1932a) did not designate a holotype in the original description of *Paratemnus assimilis,* and thus a lectotype has been selected and labelled accordingly. Three syntypes from Mommangan were not present in ZMB and could not be located for study.

Even though there is a moderate amount of variation in the size of this species, all of the specimens examined possess finely granulate anterior margins of the palpal femur and relatively slender fourth tibiae, and are thus considered conspecific. The south-east Asian species of the genus are badly in need of revision, and the key presented for the genus by Beier (1932a, 1932c) often relies on small differences in the size or thickness of the palpal segments and legs. Even though I have not been able to make comparisons with other species of the genus, the form of the male genitalia may provide very useful characters with which to reanalyse the specific status of the species within this complex genus. The form of the male genitalia of *P. assimilis* appears to be more similar to the atemnine genus *Oratemnus* and the Miratemninae than to the atemnines *Atemnus* and *Titanatemnus* (Chamberlin 1933, 1939, Vachon 1938). The orientation of the lateral rod in *Paratemnus, Oratemnus* and the three miratemnine genera is probably plesiomorphic, while the form recorded for *Atemnus* and *Titanatemnus,* with its reversed lateral rod (Vachon 1938) appears to be apomorphic. The male genitalia of the other atemnine genera have yet to be described.

Tullgren (1912) recorded this species as *Chelifer birmanicus* Thorell from Krakatau based on material collected by E. Jacobson in 1908. I have examined Jacobson's material and it is clearly not conspecific with *C. birmanicus,* now placed in the genus *Catatemnus* (Beier, 1932a, 1932c). Tullgren (1912) erroneously claimed that only nymphs were present in the Krakatau collection.

Chernetidae

Haplochernes Beier

Haplochernes warburgi (Tullgren)

Figures 96–104

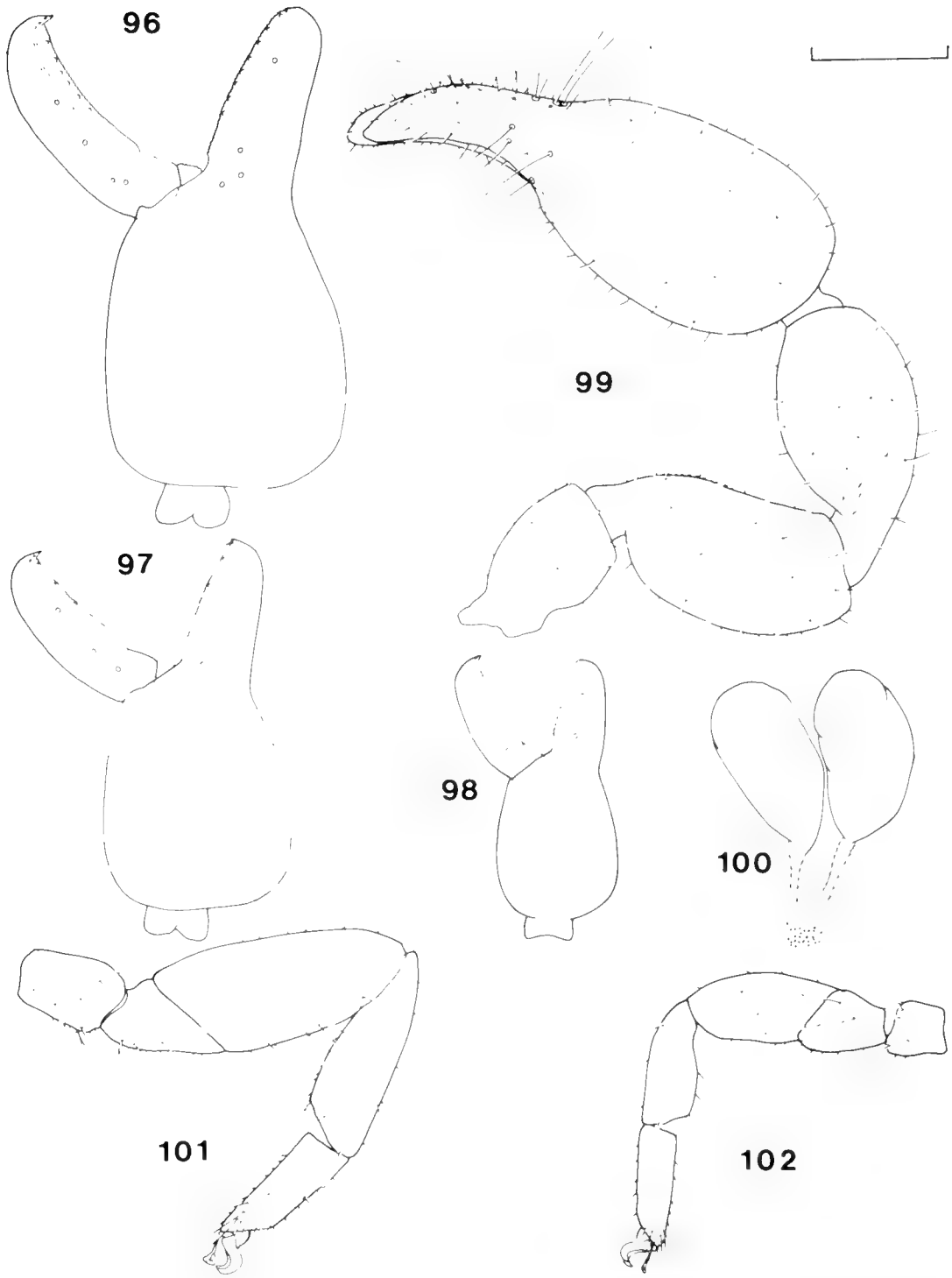
Chelifer warburgi Tullgren, 1905: 42–43, figs 3a–b.
Haplochernes warburgi.—Beier, 1932c: 112, fig. 129.—Weidner, 1959: 114.—Beier, 1965: 774–775.—Beier, 1973: 50.

Type material. Holotype ♀, Java, Nov 1890 (ZMH, SP).

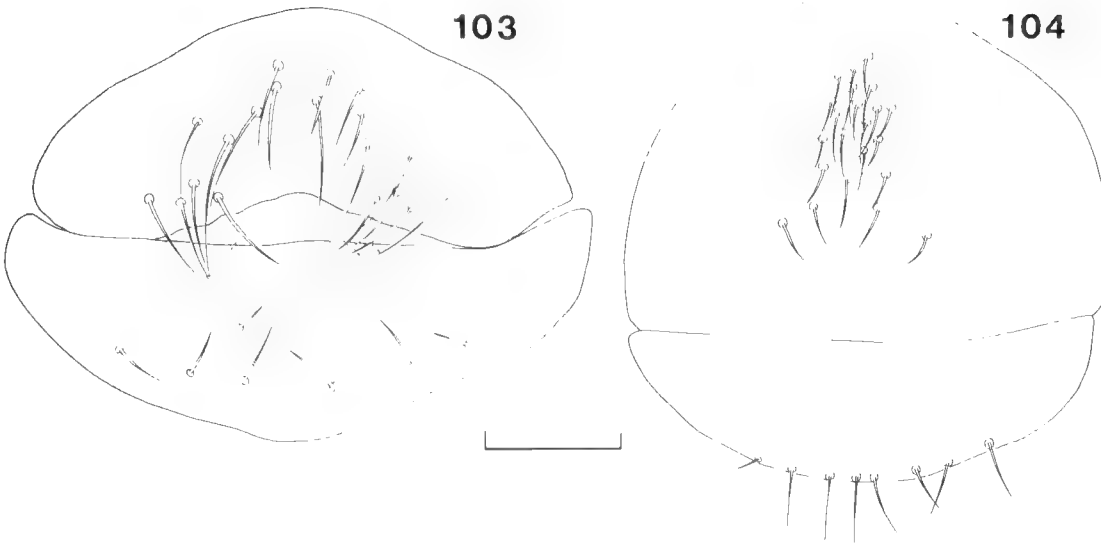
Other material examined. Krakatau Islands. Rakata, Zwarte Hoek, 6°09′S, 105°25′E: 31 Aug 1984, 3 ♂, 1 ♀ (MZB, 104-8B, MH823.02-05, SP); 22 Sep 1984, 1 ♀ (MZB, 122-BB, MH830.01, SL); beating, 12 Sep 1984, 1 ♂, 1 deutonymph (NMV, 121-AC, MH831.01-02, SL); in tent, 16 Sep 1984, 1 ♂ (ANIC, 121-AZ, MH832.01, SL); 21 Sep 1984, 1 ♀ (ANIC, 136-1A, MH833.01, SL); on table, 12 Sep 1984, 1 ♀ (with brood-sac) (NMV, 121-V, MH835.01, SL); on jerrycans, 3 Sep 1984, 1 tritonymph (NMV, 172-AA, MH834.01, SL). Rakata: Owl Bay, 6°09′S, 105°28′E, 22 Sep 1984, 1 ♀ (with brood-sac) (MZB, 100-7B, MH836.01, SL); south ridge, 6°10′S, 105°26′E, 20–50 m, beating, 25 Aug 1985, 1 ♂ (MZB, 224-GM, MH841.02, SP); 100 m, 4 Sep 1984, 1 ♀, 1 tritonymph (MZB, 178-A, MH838.02-03, SL); 850 feet (259 m), beating, 19 Sep 1984, 1 ♀ (NMV, 107-10, MH845.01, SP); west ridge, 6°09′S, 105°25′–26′E, 250 m, on human, 1 Sep 1984, 1 ♂ (MZB, 177-N, MH847.01, SP); beating, 1 deutonymph (MZB, 177-M, MH848.01, SL); 850 feet (259 m), beating, 16 Sep 1984, 2 tritonymphs (MZB, 166-1A, MH849.01-02, SL); 850–1100 feet (259–335 m), beating, 19 Sep 1984, 1 deutonymph (NMV, 107-3A, MH850.01, SL). Sertung, 6°05′S, 105°23′E: 100 feet (30 m), beating, rainforest, 11 Sep 1984, 3 ♂ (NMV, 175-B, MH854.01-03, SP); 250 feet (76 m), beating, 11 Sep 1984, 1 ♂, 1 ♀ (ANIC, 175-A, MH855.01-02, SP); rainforest, sweeping, 19 Aug 1985, 1 ♂ (MZB, 245-HC, MH856.01, SP); rainforest, sweeping, 19 Aug 1985, 1 ♂ (MZB, 245-LZD, MH857.01, SP). Sertung, spit, 6°04′S, 105°24′–25′E, beating, *Casuarina equisetifolia,* 18 Aug 1985, 2 ♂, 1 ♀, 1 deutonymph (MZB, 244-AO, MH858.01-04, SP). Panjang, 6°05′S, 105°28′E: beating, 19 Sep 1984, 1 ♂ (MZB, 176-AA, MH860.01, SL); 16 Aug 1985, 1 ♂, 1 ♀ (NMV, 234-DR, MH867.01-02, SL); sweeping, 16 Aug 1985, 1 deutonymph (MZB, 235-CV, MH881.01, SP); 100 feet (30 m), beating, 15 Sep 1984, 3 ♂ (MZB, 176-A, MH865.01-03, SP); 14 Sep 1984, 1 ♂, 1 tritonymph (NMV, 176-AB, MH864.01-02, SP). Panjang, north, 6°05′S, 105°28′E, beating, 20 Sep 1984, 1 ♂ (MZB, 138-4D, MH859.01, SP). Java. Ujung Kulon: Cidaon, 6°46′S, 105°15′E, on branch, 22 Sep 1984, 1 ♂ (MZB, 14-B, MH818.01, SL); Gunung Payung, summit (480 m), 6°49′S, 105°16′E, beating, 12 Sep 1984, 1 deutonymph (MZB, 64-3C, MH819.01, SL).

Diagnosis. With its very deep chela, smooth pedipalpal tibia, yet denticulate anterior margins of femur and chela, this species most closely resembles *H. boninensis* Beier which is only slightly smaller in size.

Description. Adults: pedipalps and carapace dark brown, legs and tergites lighter. Derm of pedipalps



Figures 96–102. *Haplochernes warburgi* (Tullgren). Figs 96, 99, 100, female, MH833.01. Fig. 97, tritonymph, MH834.01. Fig. 98, deutonymph, MH848.01. Figs 101, 102, 104, female, MH836.01. Fig. 103, male, MH818.01. Fig. 96, left chela, lateral. Fig. 97, left chela, lateral. Fig. 98, left chela, lateral. Fig. 99, right pedipalp, dorsal. Fig. 100 Spermathecae, ventral. Fig. 101, left leg IV. Fig. 102, left leg I. Scale line = 0.25 mm (figs 96–99, 101–102), 0.10 mm (fig. 100).



Figures 103, 104. *Haplochernes warburgi* (Tullgren) cont. Fig. 103, genital opercula, ventral. Fig. 104, genital opercula, ventral. Scale line = 0.07 mm.

smooth, except for anterior margin of femur and internal margin of chelal hand near base of fingers which are finely denticulate; carapace and tergites slightly rugose. Pedipalp (Fig. 99) very stout: trochanter 1.71–1.86 (♂), 1.66–1.79 (♀), femur abruptly pedicellate 2.19–2.35 (♂), 2.06–2.32 (♀), tibia 1.83–2.19 (♂), 1.83–2.13 (♀), chela (with pedicel) 2.27–2.54 (♂), 2.41–2.76 (♀), chela (without pedicel) 2.14–2.40 (♂), 2.27–2.61 (♀), hand 1.24–1.50 (♂), 1.41–1.48 (♀) times as long as broad, chelal hand very deep. Fixed chelal finger with 8 trichobothria, moveable chelal finger with 4 trichobothria (Fig. 96); *eb* and *esb* adjacent, *est* much closer to *esb* than to *et*, internal series basal, *b* and *sb* adjacent, *st* slightly closer to *sb* than to *t* (one male is lacking *sb* and *st* from one finger). Venom apparatus present in moveable chelal finger terminating in nodus ramosus proximal to *t*. Fixed finger with 38–41 (♂), 37–44 (♀) marginal teeth, plus 5–7 (♂), 7–8 (♀) external accessory teeth; moveable finger with 43–45 (♂), 46–53 (♀) marginal teeth, plus 5–8 (♂), 6–9 (♀) external accessory teeth. Chelicera with 5 setae on hand, *sbs*, *bs* and *es* finely denticulate; serrula exterior of 20–21 (♂), 20–22 (♀) lamellae; flagellum of 3 blades, anterior blade with spinules on anterior margin, central blade occasionally with 1 distal spinule; galea with 6–8 rami, distributed along length of galea, basal rami often longest, not sexually dimorphic. Carapace with 6 (♂), 6–8 (♀) setae on posterior margin, 1.25–1.29 (♂), 1.12–1.32 (♀) times as long as broad; 2 eye spots present; 2 furrows present, anterior furrow moderately deep, posterior furrow shallow, closer to posterior edge of carapace than to anterior furrow. Tergites V–X and sternites V–X medially divided, often slightly. Tergal chaetotaxy: ♂, 6-7: 6: 6: 6–9: 9: 9–10: 10–12: 10–13: 12–15: 14–15: 12: 2; ♀, 7–9: 6–8: 7–8: 8–9: 9–10: 11–12: 12–13: 13–14: 13–15: 16–17: 13–14: 2. Sternal chaetotaxy: ♂, 19–23: (2–3)8–10[5–7](2–3): (1)4–5(1): 11–14: 12–14: 11–13: 13–17: 13–16: 14–18: 10–12: 2; ♀, 22–23: (3)8–10(3): (1)3–4(1): 12–16: 14–16: 13–14: 16–18: 16–17: 17–19: 13–14: 2. Coxal chaetotaxy: ♂, 9–11: 8–12: 8–11: 13–18; ♀, 10: 9–12: 10–11: 38–41 (the latter includes several setae on dorsal edge above pedal foramen). Male genital opercula as in Fig. 103. Female genital opercula (Fig. 104): anterior operculum with tight, longitudinal cluster of setae. Male genitalia not unusual for family. Female spermathecae of 2 tubules ending in large inflated sacs (Fig. 100). Legs (Figs 101, 102): monotarsate; femoral junction of legs I and II oblique; subterminal tarsal seta simple, curved; leg IV with 1 tactile seta medially on tarsus, TS = 0.38–0.43 (♂), 0.41–0.45 (♀); all tarsi with proximal elevated slit sensillum; claws simple; arolium as long as claws.

Dimensions (mm), ♂ (♀): body length 2.45–3.07 (2.27–3.59); pedipalps: trochanter 0.325–0.36/0.18–0.205 (0.34–0.375/0.20–0.21), femur 0.54–0.64/0.23–0.275 (0.535–0.595/0.25–0.26), tibia 0.515–0.605/0.235–0.315 (0.525–0.565/0.265–0.30), chela (with pedicel) 0.865–0.935/0.34–0.405 (0.94–1.005/0.355–0.40), chela (without

pedicel) 0.815–0.875 (0.885–0.93), moveable finger length 0.36–0.41 (0.395–0.46), hand length 0.42–0.575 (0.505–0.56); chelicera 0.245–0.28/0.13–0.14 (0.27–0.28/0.14–0.155), moveable finger length 0.20–0.215 (0.21–0.22); carapace 0.655–0.70/0.51–0.555 (0.635–0.765/0.54–0.60); leg I: trochanter 0.115–0.13/0.095–0.105 (0.115–0.13/0.11), basifemur 0.155–0.185/0.11–0.13 (0.175–0.18/0.12–0.13), telofemur 0.28–0.335/0.135–0.16 (0.30–0.335/0.145–0.155), tibia 0.24–0.285/0.095–0.11 (0.255–0.28/0.105–0.11), tarsus 0.23–0.26/0.07–0.075 (0.245–0.255/0.07–0.075); leg IV: trochanter 0.20–0.235/0.13–0.145 (0.20–0.235/0.14–0.145), basifemur 0.21–0.235/0.14–0.185 (0.245–0.25/0.165–0.185), telofemur 0.44–0.50/0.20–0.23 (0.475–0.505/0.21–0.225), tibia 0.385–0.44/0.12–0.135 (0.41–0.425/0.13–0.14), tarsus 0.275–0.315/0.085–0.095 (0.285–0.30/0.095–0.10), distance of tarsal tactile seta from proximal margin 0.115–0.135 (0.12–0.13).

Tritonymphs: colour paler than adults. Pedipalp: trochanter 1.59–1.68, femur 2.24–2.29, tibia 1.80–1.98, chela (with pedicel) 2.44–2.65, chela (without pedicel) 2.23–2.48, hand 1.30–1.37 times as long as broad. Fixed chelal finger with 7 trichobothria, moveable chelal finger with 3 trichobothria (Fig. 97); *ist* and *sb* absent. Serrula exterior of chelicera with 16–18 lamellae; galea with 2–3 medial to subdistal and 2 distal rami. Carapace with 6–7 setae on posterior margin; 1.14–1.27 times as long as broad. Tergal chaetotaxy: 6–7: 5–6: 6–7: 6–8: 7–9: 8–9: 10: 10–12: 12: 13–15: 10–12: 2. Sternal chaetotaxy: 4–7: (2)5–6(2): (1)4–5(1): 8–12: 11–14: 12–14: 12: 12–15: 12–14: 10–11: 2. Coxal chaetotaxy: 6–8: 6–8: 6–9: 9–14. Monotarsate.

Dimensions (mm): body length 2.24–2.74; pedipalps: trochanter 0.255–0.28/0.155–0.175, femur 0.435–0.47/0.19–0.21, tibia 0.37–0.455/0.205–0.23, chela (with pedicel) 0.715–0.78/0.27–0.32, chela (without pedicel) 0.67–0.715, moveable finger length 0.325–0.335, hand length 0.37–0.415; carapace 0.57–0.615/0.485–0.50.

Deutonymphs: colour very pale. Pedipalp: trochanter 1.57–1.67, femur 2.00–2.13, tibia 1.57–1.69, chela (with pedicel) 2.64–2.80, chela (without pedicel) 2.47–2.58, hand 1.33–1.38 times as long as broad. Fixed chelal finger with 6 trichobothria, moveable chelal finger with 1 trichobothrium (Fig. 98); *esb*, *ist*, *sb* and *st* absent. Serrula exterior of chelicera with 15–17 lamellae; galea with 2 medial and 2 distal rami. Carapace with 6 setae on posterior margin; 1.18–1.21 times as long as broad. Tergal chaetotaxy: 5–6: 5–7: 5–6: 6: 5–6: 6–7: 6–7: 8: 8–10: 10: 8: 2. Sternal chaetotaxy: 0: (1)4(1): (1)4(1): 6–10: 8–10: 8–10: 8–10: 10: 9–10: 8–10: 2. Coxal chaetotaxy: 4: 4–5: 4–5: 5. Monotarsate.

Dimensions (mm): body length 1.97–2.13; pedipalps: trochanter 0.18–0.22/0.115–0.135, femur 0.27–0.33/0.13–0.155, tibia 0.245–0.275/0.145–0.175, chela (with pedicel) 0.495–0.595/0.18–0.225, chela (without pedicel) 0.46–0.555, moveable finger length 0.24–0.27, hand length 0.24–0.30; carapace 0.44–0.51/0.365–0.43.

Remarks. This species has also been reported from Sulawesi, Papua New Guinea and Sri Lanka.

Haplochernes kraepelini (Tullgren)

Figures 105–112

Chelifer kraepelini Tullgren, 1905: 40–42, figs 2a–d. – Ellingsen, 1910: 367.

Haplochernes kraepelini. – Beier, 1932c: 113, fig. 130. – Beier, 1957: 33, figs 18a–b. – Weidner, 1959: 114.

Type material. Lectotype ♀ (present designation), Buitenzorg [now Bogor], Java, 8 Mar 1904 (ZMH, SP).

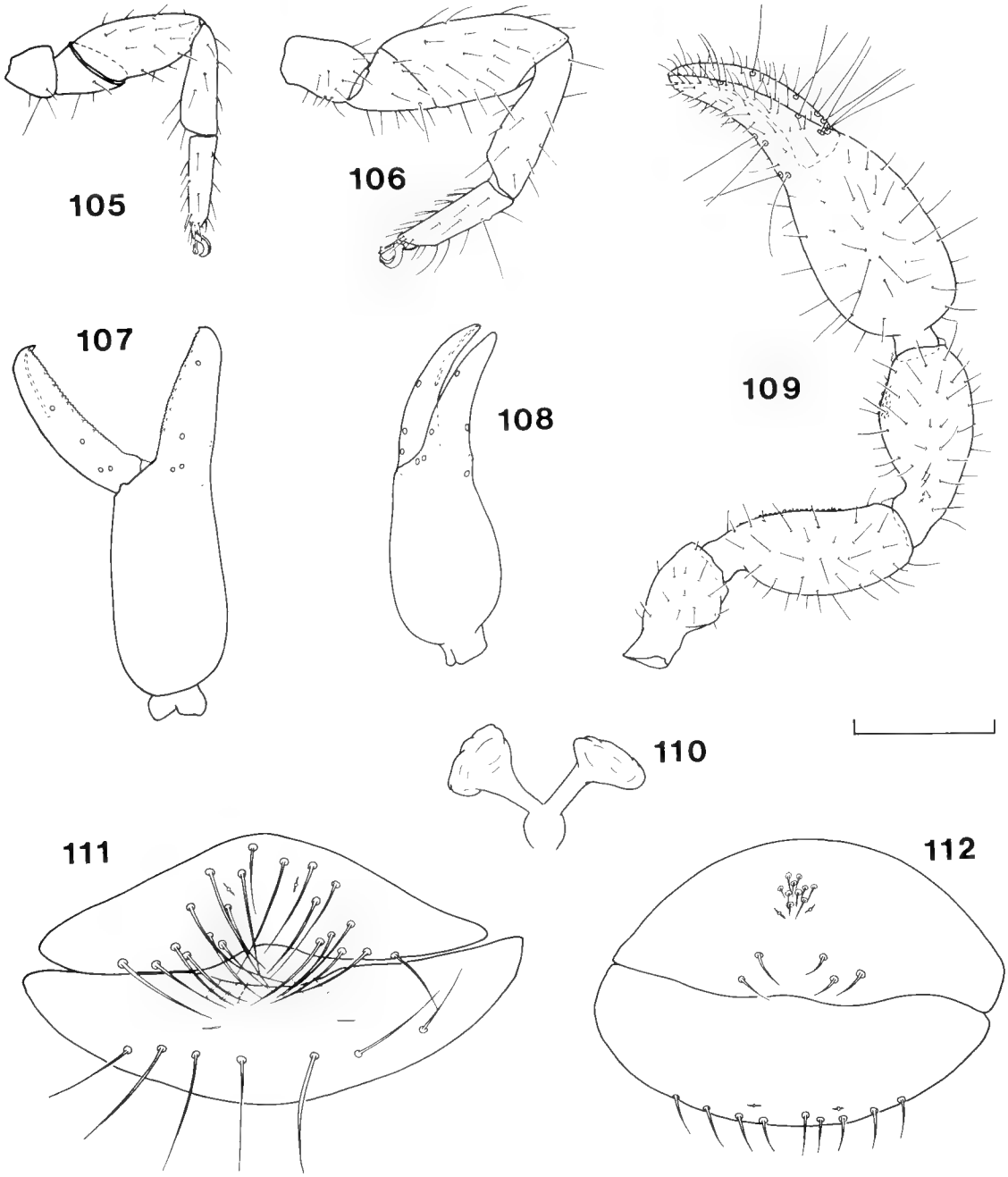
Paralectotypes: 4 ♀ (2 with brood-sacs), 3 ♂, 4 tritonymphs, same data as lectotype (ZMH, SP); 2 ♀ (with brood-sacs), 2 ♂, same data as lectotype except Mar 1904 (ZMH, SP). Also included in the syntype series is a male of *Oratemnus proximus* Beier (Atemnidae) (see below).

Other material examined. Krakatau Islands. Rakata, south ridge, 6°10′S, 105°26′E: 50–100 m, beating, 26 Aug 1985, 1 ♀ (MZB, 224-IU, MH839.01, SL); 400 m, beating, 24 Aug 1985, 1 ♂ (MZB, 224-DI, MH840.01, SL). Java. 1 km E of Carita, 6°16′S, 105°50′E, under bark of tree, rainforest, Aug 1984, 1 ♂, 5 ♀, 1 tritonymph (1 ♂, 2 ♀ in NMV, 1 ♀ in ANIC, remainder in MZB, 115-A, MH806.01-07, SL).

Diagnosis. This species shares with *H. hebridicus* Beier a granulate anterior face of the pedipalpal femur and tibia, and a smooth and virtually cylindrical chela. However, *H. hebridicus* has a more slender chelal hand (1.82 times as long as broad) compared with *H. kraepelini* (1.53–1.63 times as long as broad).

Description. Adults: pedipalps and carapace dark red-brown, legs and tergites lighter. Derm fairly smooth, except for pedipalpal trochanter, anterior face of pedipalpal femur and tibia, and anterior portion of carapace, which are granulate. Pedipalp (Fig. 109): trochanter 1.52–1.78 (♂), 1.60–1.84 (♀), femur pedicellate 2.46–2.59 (♂), 2.32–2.63 (♀), tibia 2.07–2.16 (♂), 2.03–2.19 (♀), chelal hand not particularly deep, 1.59–1.63 (♂), 1.53–1.57 (♀), chela (with pedicel) 2.92–3.15 (♂), 2.85–3.01 (♀), chela (without pedicel) 2.74–2.96 (♂), 2.69–2.85 (♀), hand 1.59–1.63 (♂), 1.53–1.57

(♀) times as long as broad. Fixed chelal finger with 8 trichobothria, moveable chelal finger with 4 trichobothria; *eb* and *esb* adjacent, *est* much closer to *esb* than to *et*, *it* and *ist* adjacent and close to *ib* and *isb*, *b* and *sb* adjacent, *st* closer to *sb* than to *t* (Fig. 107). Venom apparatus present in move-



Figures 105–112. *Haplochernes kraepelini* (Tullgren). Figs 105–107, 109, 110, 112, female, MH806.02. Fig. 108 tritonymph, MH806.07. Fig. 111, male, MH806.01. Fig. 105, left leg I. Fig. 106, left leg IV. Fig. 107, left chela, lateral. Fig. 108, left chela, dorsal. Fig. 109, right pedipalp, dorsal. Fig. 110 Spermathecae, ventral. Fig. 111, genital opercula, ventral. Fig. 112, genital opercula, ventral. Scale line = 0.35 mm (fig. 105–106), 0.40 mm (figs 107, 109), 0.49 mm (fig. 108), 0.07 mm (fig. 110), 0.10 mm (figs 111–112).

able chelal finger terminating in nodus ramosus near *t*. Fixed finger with 52–57 (♂), 60 (♀) marginal teeth, plus 8–9 (♂, ♀) external accessory teeth; moveable finger with 51–63 (♂), 58–67 (♀) marginal teeth, plus 4–9 (♂), 6–8 (♀) external accessory teeth. Chelicera with 5 setae on hand, *bs*, *sbs* and *es* denticulate, *ls* and *is* longest; serrula exterior of 17–20 (♂), 16–20 (♀) lamellae; flagellum of 3 blades, anterior blade with several spinules on anterior face; galea of male and female similar, with 5–6 distal to subdistal rami. Carapace with 6–9 (♂), 6–11 (♀) setae on posterior margin, 1.11–1.25 (♂), 1.02–1.27 (♀) times as long as broad; 2 eye spots present; with median furrow. Tergites III–X and sternites V–X divided. Tergal chaetotaxy: ♂, 8–10: 10–13: 10–13: 12–15: 14–18: 16–18: 16–19: 16–19: 16–19: 15–20: 11–14: 2; ♀, 10–12: 10–12: 11–13: 11–15: 16–18: 16–19: 17–18: 16–20: 16–20: 17–20: 10–14: 2. Sternal chaetotaxy: ♂, 20–22: (3)6–11[4–6](3): (1)5–8(1): 13–19: 16–20: 16–21: 16–20: 15–19: 16–20: 10–14: 2; ♀, 13–19: (3)8–10(3): (1)6–9(1): 17–22: 17–21: 17–21: 18–21: 18–20: 16–20: 10–12: 2. Coxal chaetotaxy: ♂, 12–16: 9–17: 11–16: 14–19; ♀, 10–14: 8–12: 9–13: 28–43. Male genital opercula as in Fig. 111. Female genital opercula as in Fig. 112. Male genitalia not unusual for family. Female spermathecae (Fig. 110) with 2 tubules terminating in large, inflated bulbs.Legs (Figs 105, 106): monotarsate; femoral junction of legs I and II oblique; leg IV with tactile seta on tarsus, TS = 0.29–0.32 (♂), 0.29–0.31 (♀); subterminal tarsal seta simple, curved; all tarsi with proximal elevated slit sensillum; claws simple; arolium shorter than claws.

Dimensions (mm), ♂ (♀): body length 2.21–2.85 (2.47–3.56); pedipalps: trochanter 0.435–0.50/0.255–0.33 (0.375–0.465/0.22–0.265), femur 0.68–0.81/0.265–0.325 (0.62–0.73/0.245–0.305), tibia 0.62–0.745/0.30–0.345 (0.59–0.70/0.27–0.34), chela (with pedicel) 1.175–1.32/0.38–0.445 (1.10–1.315/0.365–0.44), chela (without pedicel) 1.07–1.24 (1.02–1.245), moveable finger length 0.495–0.57 (0.435–0.59), hand length 0.605–0.62 (0.58–0.64); chelicera 0.255–0.275/0.115–0.15 (0.25–0.28/0.115–0.17), moveable finger length 0.20–0.225 (0.195–0.225); carapace 0.73–0.84/0.635–0.73 (0.67–0.845/0.635–0.745); leg I: trochanter 0.145–0.165/0.135–0.15 (0.145–0.165/0.13–0.155), basifemur 0.21–0.205/0.14–0.15 (0.19–0.22/0.14–0.165), telofemur 0.36–0.37/0.15–0.165 (0.35–0.445/0.165–0.18), tibia 0.30–0.325/0.10 (0.30–0.35/0.095–0.12), tarsus 0.255–0.29/0.07–0.075 (0.265–0.30/0.065–0.075); leg IV: trochanter 0.25–0.26/0.145–0.175 (0.245–0.27/0.16–0.195), basifemur 0.265–0.29/0.18–0.205 (0.245–0.29/0.18–0.21), telofemur 0.51–0.60/0.235–0.27 (0.495–0.565/0.225–0.27), tibia 0.47–0.55/0.135–0.15 (0.495–0.54/0.13–0.165), tarsus 0.32–0.355/0.09–0.095 (0.305–0.35/0.085–0.10), distance of tarsal tactile seta from proximal margin 0.095–0.115 (0.095–0.10).

Tritonymphs: colour paler than adults. Pedipalp: trochanter 1.67–1.71, femur 2.07–2.43, tibia 1.93–2.08, chela (with pedicel) 2.84–3.00, chela (without pedicel) 2.67–2.84, hand 1.73 times as long as broad. Fixed chelal finger with 7 trichobothria, moveable chelal finger with 3 trichobothria (Fig. 108); *ist* and *sb* absent. Serrula exterior of chelicera with 18 lamellae; galea medially bifurcate, each bifurcation with 2 distal rami. Carapace with 4 setae on posterior margin; 1.15–1.42 times as long as broad. Tergal chaetotaxy: 8–10: 6–8: 7–8: 10: 14–15: 14–16: 14–17: 14–16: 16–17: 16: 12: 2. Sternal chaetotaxy: 3: (2)6(2): (1)6(1): 14: 14: 13: 15: 17: 14: 12: 2. Coxal chaetotaxy: 5: 7: 6: 9. Monotarsate.

Dimensions (mm): body length 2.09–2.56; pedipalps: trochanter 0.275–0.30/0.165–0.175, femur 0.425–0.455/0.175–0.205, tibia 0.405–0.425/0.195–0.22, chela (with pedicel) 0.765–0.81/0.255–0.285, chela (without pedicel) 0.725–0.76, moveable finger length 0.385–0.39, hand length 0.44–0.45; carapace 0.575–0.61/0.405–0.53.

Remarks. Due to the presence of two species in the syntype series, a lectotype has been designated. The second species, *Oratemnus proximus* (Atemnidae), has hitherto only been reported from Sumatra (Beier, 1932a, 1933) and Sri Lanka (Beier, 1973), and this is the first record of this species from Java. As the only measurements of this species that have been presented in the literature are of the male holotype (Beier, 1932a, 1933), some measurements of the male from Bogor are given (the ratios are in parentheses): body length 3.13, pedipalps: femur 0.685/0.26 (2.63), tibia 0.635/0.30 (2.12), chela (with pedicel) 1.035/0.355 (2.92), chela (without pedicel) 1.015 (2.86), moveable finger length 0.415.

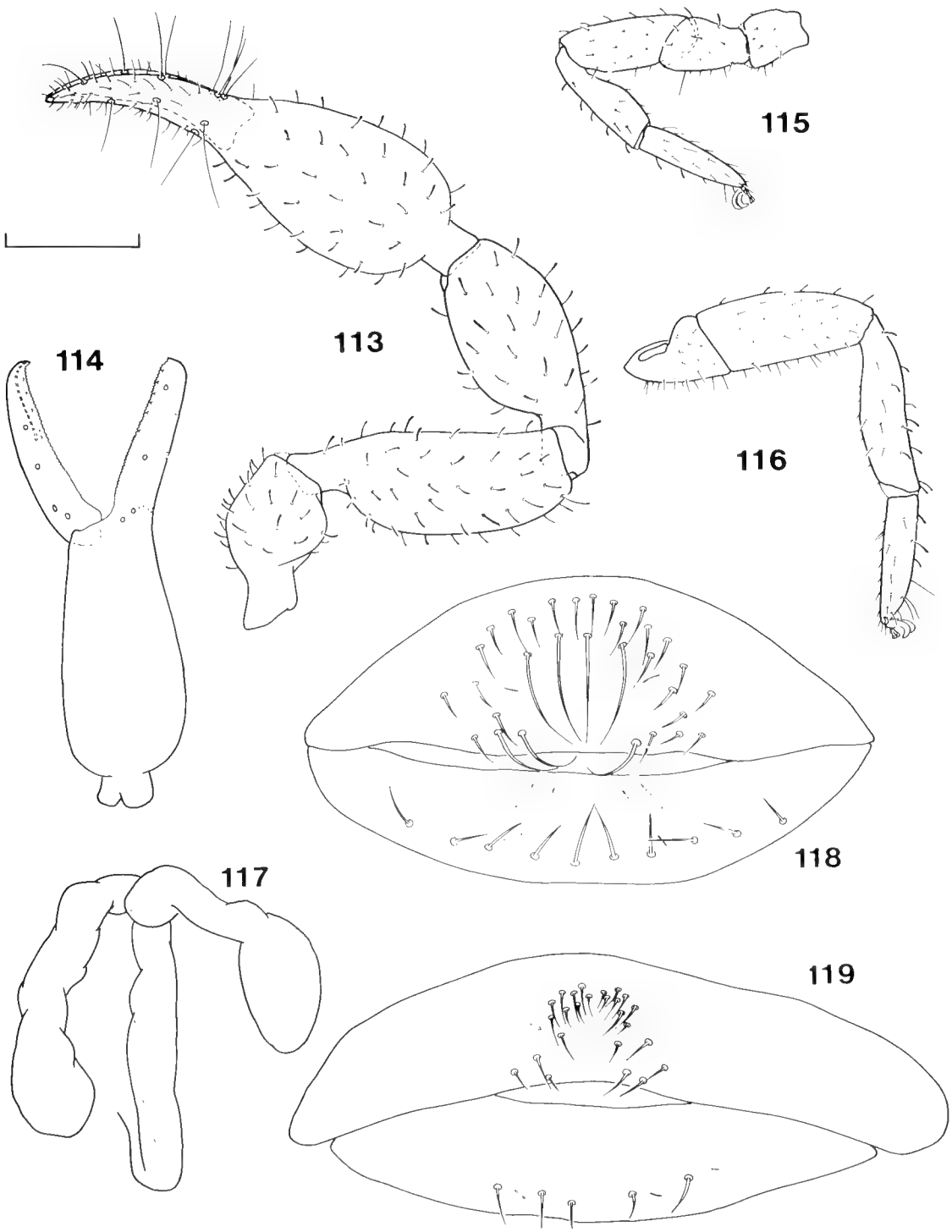
Haplochernes kraepelini is known from Java, Krakatau, the Palau Islands and the Caroline Islands in Micronesia.

Allochernes Beier

Allochernes liwa sp. nov.

Figures 113–119

Type material. Holotype ♀, 7 km W of Liwa, Sumatra, 5°04'S, 104°03'E, 640 m, beating at forest edge, 1 Sep 1984 (MZB, 111-7G, MH810.01, SL).



Figures 113–119. *Allochernes liwa* sp. nov. Figs 113-117, 119, holotype female. Fig. 118, paratype male, MH810.02. Fig. 113, right pedipalp, dorsal. Fig. 114, left chela, lateral. Fig. 115, left leg I. Fig. 116, left leg IV. Fig. 117 Spermathecae. Fig. 118, genital opercula. Fig. 119, genital opercula. Scale line 0.30 mm (figs 113–116), 0.07 mm (fig. 117), 0.09 mm (figs 118–119).

Paratypes: 1 ♀, 1 ♂, same data as holotype (♀ in NMV, K744, ♂ in MZB, 111-7G, MH810.02-03, SL).

Diagnosis. Without a complete revision of Asian members of this genus, it is difficult to assess the relationships of this species. It differs from other species of the genus by the shape and size of the pedipalpal segments.

Description. Pedipalps deep red-brown, carapace, legs and tergites lighter. Derm of pedipalps, carapace and tergites slightly granulate. Pedipalp (Fig. 113): trochanter 1.60 (♂), 1.58–1.77 (♀), femur strongly pedicellate, 2.52 (♂), 2.74–2.92 (♀), tibia pedicellate 2.19 (♂), 2.27–2.38 (♀), chela (with pedicel) 3.19 (♂), 3.32–3.43 (♀), chela (without pedicel) 2.95 (♂), 3.08–3.17 (♀), hand 1.60 (♂), 1.69–1.71 (♀) times as long as broad. Fixed chelal finger with 8 trichobothria, moveable chelal finger with 4 trichobothria; ist slightly anterior to *est*, *ist* slightly closer to *it* than *ist* (Fig. 114). Venom apparatus present in moveable chelal finger terminating in nodus ramosus proximal to *t*. Fixed finger with 37 (♀) marginal teeth, plus 5–6 external and 2 internal accessory teeth; moveable finger with 42 (♀) marginal teeth, plus 3 external and 1 internal accessory teeth. Chelicera with 5 setae on hand, *sbs* and *bs* denticulate, one specimen has an extra seta between *ls* and *sbs* on one chelicera; serrula exterior of 17–18 (♂), 18–20 (♀) lamellae; flagellum of 3 blades, anterior blade longest and widest, first 2 with spinules on anterior face, last terminally bifid; galea of male simple, of female with 2 distal, 3 medial and 1 basal rami. Carapace with 8 (♂), 9–11 (♀) setae on posterior margin, 1.26 (♂), 1.07–1.08 (♀) times as long as broad; 2 eye spots present, barely discernible; posterior transverse furrow closer to posterior margin of carapace than to anterior furrow. Tergites I–X and sternites IV–X with broad division. Tergal chaetotaxy: ♂, 11: 12: 11: 15: 15: 15: 15: 14: 15: 14: 8: 2; ♀, 14: 13–14: 13: 19–20: 18: 16–18: 18–20: 16–19: 16–18: 14–15: 6: 2. Sternal chaetotaxy: ♂, 33: (3)10 [4] (2): (2)6(2): 16: 19: 18: 16: 17: 14: 8: 2; ♀, 22–25: (2)5(2): (2)4–6(2): 15–17: 23–24: 22–24: 21–22: 20: 15–16: 8–10: 2. Coxal chaetotaxy: ♂, 14: 14: 18: 28; ♀, 14–16: 14–18: 22–23: 42–45 (the latter includes several setae on dorsal edge above pedal foramen). Male genital opercula (Fig. 118) with 2 pairs of long thick setae, remaining setae normal. Female genital opercula (Fig. 119) with mostly short setae. Male genitalia not unusual for family. Female genitalia with long, T-shaped spermathecae (Fig. 117). Legs (Figs 115, 116): monotarsate; femoral junction of legs I and II oblique; subterminal tarsal seta curved simple; all tarsi with proximal elevated slit sensillum; claws simple; arolium as long as claws; leg IV without tactile setae, although a medium-sized 'pseudotactile' seta is present distally.

Dimensions (mm), ♂ (♀): body length 1.92 (2.65–2.75); pedipalps: trochanter 0.375/0.235 (0.41–0.415/0.235–0.26), femur 0.63/0.25 (0.685–0.73/0.25), tibia 0.58/0.265 (0.625–0.655/0.275), chela (with pedicel) 1.005/0.315 (1.08–1.115/0.325), chela (without pedicel) 0.93 (1.00–1.03), moveable finger length 0.465 (0.475–0.515), hand length 0.505 (0.55–0.555); chelicera 0.235/0.115 (0.26–0.265/0.13–0.135), moveable finger length 0.16 (0.195–0.27); carapace 0.765/0.605 (0.725–0.745/0.68–0.69); leg I: trochanter 0.13/0.11 (0.155–0.16/0.13–0.135), basifemur 0.185/0.135 (0.22–0.28?/0.145), telofemur 0.195/0.11 (0.35–0.355/0.125–0.13), tibia 0.255/0.08 (0.305/0.085–0.08), tarsus 0.265/0.07 (0.285–0.29/0.07); leg IV: trochanter 0.24/0.15 (0.295/0.16–0.175), basifemur 0.23/0.145 (0.255–0.265/0.16), telofemur 0.385/0.155 (0.45–0.46/0.165–0.175), tibia 0.40/0.10 (0.45–0.475/0.10–0.105), tarsus 0.31/0.075 (0.335–0.36/0.08).

Remarks. Even though species of the predominately European genus *Allochernes* have been recorded from some of the more northern Asian countries such as Nepal, China and Japan, *A. liwa* is the first species of the genus to be recorded from south-east Asia.

Verrucachernes Chamberlin

Verrucachernes oca Chamberlin

Figures 120–127

Verrucachernes oca Chamberlin, 1947: 313–316, figs 3a–i. – Beier, 1957: 39–40, figs 23a–d. – Beier, 1965: 777. – Beier, 1966a: 147. – Beier, 1970: 324.

Microchernes orientalis Beier, 1951: 92–93, fig. 27. – Beier, 1973: 51. Syn. nov.

Microchernes insularis Beier, 1953: 84–86, fig. 4. Syn. nov.

Verrucachernes orientalis. – Beier, 1957: 40.

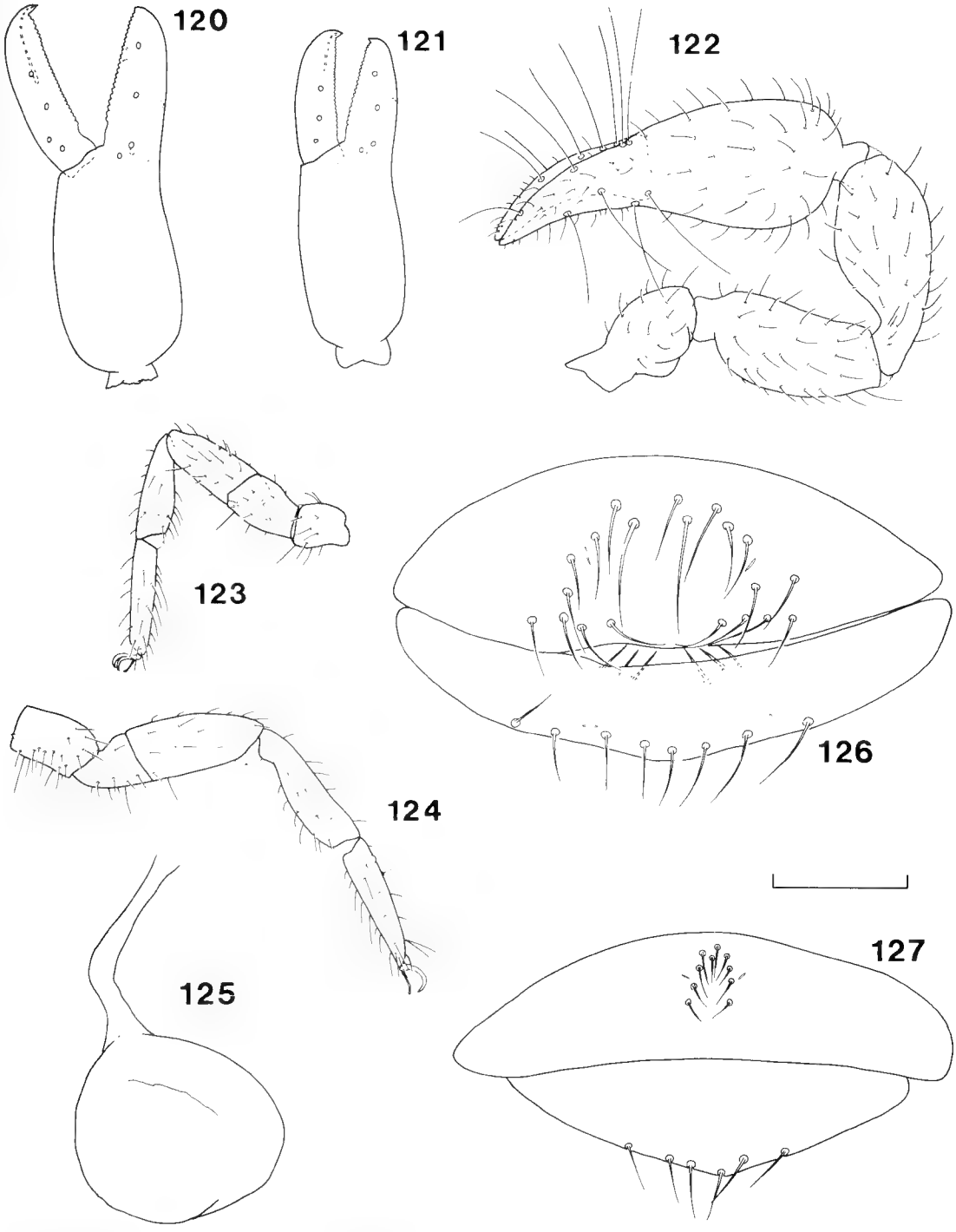
Verrucachernes insularis. – Beier, 1957: 40.

Type material. Verrucachernes oca: holotype ♀, Oca Point, Guam, 10 Aug 1945, Fritts (JCC?, JC-2067.02001, not examined).

Paratypes: 1 tritonymph, same data as holotype (JCC?, JC-2067.02002, not examined); 1 tritonymph, same data except 11 Sep 1945, G.W. Wharton (JCC?, JC-2067.04001, not examined).

Microchernes orientalis: lectotype ♀ (present designation), Hatien [Ha Tien], Vietnam, Mar 1939, C. Dawydoff (NMHW, SP).

Paralectotypes: 1 ♀, 2 ♂, same data as lectotype



Figures 120–127. *Verrucachernes oca* Chamberlin. Figs 120, 122, 124, 125, 127, female, MH829.01. Fig. 121, tritonymph, MH853.25. Figs 123, 126, male, MH866.01. Fig. 120, left chela, lateral. Fig. 121, left chela, lateral. Fig. 122, right pedipalp, dorsal. Fig. 123, left leg I. Fig. 124, left leg IV. Fig. 125, spermathecae. Fig. 126, genital opercula. Fig. 127, genital opercula. Scale line = 0.20 mm (figs 120–124), 0.06 mm (fig. 125), 0.07 mm (figs 126–127).

(NHMW, SP); 1 ♂, Sré Umbell [Sré Ambel], Cambodia [now Kampuchea], Mar 1939, C. Dawydoff (NHMW, SP); 1 ♀, Réam [Phsar Ream], Cambodia [Kampuchea], Apr 1939, C. Dawydoff (MNHN); 1 ♀ (with brood-sac), Plateau Langbiang [Cao Nguyên Lâm Viên], Vietnam, C.Dawydoff (NHMW, SP).

Microchernes insularis: lectotype ♀ (present designation), Mau Marru, Sumba, 19 Jul 1949, unter Rinde eines am Boden liegenden Stammes Kleines Waldtal bein Dorf, Buhler and Sutter (NHMB, collection no. 288, SP).

Paralectotypes: 2 ♂, same data as lectotype (NHMB, collection no. 288, SP).

Other material examined. Krakatau Islands. Rakata, Zwarte Hoek, 6°09'S, 105°25'E, under bark of logs: 13 Sep 1984, 1 ♂, 3 ♀ (1 with brood-sac) (MZB, 121-O, MH824.01-04, SP); 15 Sep 1984, 2 ♂, 1 ♀ (NMV, 121-AI, MH828.01-03, SI); 15 Sep 1984, 1 ♀ (NMV, 173-I, MH829.01, SI). Sertung, 6°05'S, 105°23'E, under bark of dead *Ficus* sp. on beach, 11 Sep 1984, 10 ♂, 13 ♀ (some with brood-sacs), 1 tritonymph (2 ♂, 2 ♀ in ANIC, 3 ♂, 3 ♀ in NMV, remainder in MZB, 151-R, MH853.02-25, SI and SP). Panjang, 6°05'S, 105°28'E, under bark of log, 14 Sep 1984, 1 ♂ (MZB, 155-K, MH866.01, SI).

Diagnosis. *Verrucachernes oca* differs from the remaining two Asian species of the genus, *V. sublaevis* Beier and *V. montigenus* Beier, in its small size (e.g. the pedipalpal femur of these two species is in excess of 0.50 mm, whereas it is less than 0.43 mm in *V. oca*). It is more similar to the other two species, *V. congicus* Beier from Congo and *V. spinosus* Beier from Ivory Coast, and only a direct comparison of specimens will reveal differences, if they exist.

Description. Adults: generally pale brown, with pedipalps and carapace slightly darker. Derm of pedipalps, carapace and tergites coarsely granulate. Pedipalp (Fig. 122): trochanter 1.45–1.81 (♂), 1.59–1.76 (♀), femur pedicellate, 2.41–2.64 (♂), 2.23–2.48 (♀), tibia 2.19–2.48 (♂), 2.25–2.41 (♀), chela (with pedicel) 2.76–3.21 (♂), 2.89–3.15 (♀), chela (without pedicel) 2.77–3.02 (♂), 2.73–2.93 (♀), hand 1.45–1.61 (♂), 1.44–1.70 (♀) times as long as broad. Fixed chelal finger with 8 trichobothria, moveable chelal finger with 4 trichobothria; *eb* and *esb* adjacent, *est* midway between *esb* and *et*, *ist* slightly closer to *it* than to *isb*, *sb* and *b* adjacent, *st* midway between *sb* and *t* (Fig. 120). Venom apparatus present in moveable chelal finger terminating in nodus ramosus near *t*. Fixed finger with 29–33 (♂), 29–34 (♀) marginal teeth, plus 1–2 (♂, ♀) internal accessory teeth; moveable finger with 35–39 (♂), 34–38 (♀) marginal teeth, plus 0–2 (♂, ♀) internal accessory teeth. Chelicera with 5 setae on hand, *bs*, *sbs* and *es* finely denticulate; serrula exterior of 17 (♂), 16–18 (♀) lamellae; flagellum of 3 blades, anterior blade with spinules on anterior face; distal portion of fixed finger with large subterminal tooth; galea basically as in Chamberlin (1947, fig. 3b), but additional smaller rami may occasionally be present, not sexually dimorphic. Carapace with 8–9 (♂), 8–10 (♀) setae on posterior margin, 1.20–1.31 (♂), 1.19–1.35 (♀) times as long as broad; 2 eye spots present; 2 furrows present, median furrow moderately deep, posterior furrow shallow, closer to posterior margin of carapace than to anterior furrow. Tergites I–X and sternites IV–X divided. Tergal chaetotaxy: ♂, 9–13: 10–11: 10–11: 11–13: 11–13: 11–14: 12–14: 13: 11–13: 10–14: 8–11: 2; ♀, 10–12: 10–12: 10–12: 13–14: 13: 14–15: 14–16: 14–17: 14–16: 13–16: 8: 2. Sternal chaetotaxy: ♂, 14–20: (1)6–9 [4–6] (1): (2)5–8(2): 16–19: 17–20: 16–18: 16–19: 15–21: 12–15: 8–9: 2; ♀, 10–15: (1–2)5–6(1–2): (2)4–7(2): 14–20: 18–23: 17–20: 17–21: 15–21: 14–17: 8–9: 2. Coxal chaetotaxy: ♂, 14–16: 12–19: 15–16: 21–23; ♀, 12–18: 15–20: 15–19: 30–37. Male genital opercula as in Fig. 126. Female genital opercula (Fig. 127): anterior operculum with tight, central cluster of small setae. Male genitalia not unusual for family. Female spermathecae of 1 tubule with very large terminal bulb (Fig. 125). Legs (Figs 123–124): monotarsate; femoral junction of legs I and II oblique; subterminal tarsal seta dentate; leg IV with 1 tactile setae subproximally on tarsus, TS = 0.35–0.43 (♂), 0.32–0.39 (♀); all tarsi with proximal elevated slit sensillum; claws simple, very slender; arolium as long as claws.

Dimensions (mm), ♂ (♀): body length 1.29–1.57 (1.49–1.69); pedipalps: trochanter 0.225–0.265/0.135–0.165 (0.23–0.27/0.23–0.27), femur 0.35–0.43 0.14–0.175 (0.345–0.415/0.145–0.17), tibia 0.38–0.44/0.16–0.19 (0.36–0.435/0.16–0.185), chela (with pedicel) 0.625–0.73/0.20–0.245 (0.62–0.745/0.21–0.245), chela (without pedicel) 0.57–0.685 (0.58–0.685), moveable finger length 0.255–0.32 (0.29–0.325), hand length 0.315–0.395 (0.315–0.40); chelicera 0.18–0.21/0.095–0.085 (0.185–0.205/0.095–0.13), moveable finger length 0.14–0.16 (0.15–0.175); carapace 0.485–0.555/0.38–0.46 (0.47–0.545/0.385–0.455); leg I: trochanter 0.095–0.11/0.075–0.085 (0.10–0.11/0.075–0.09), basifemur 0.125–0.145/0.085–0.095 (0.125–0.14/0.08–0.125), telofemur 0.175–0.20/0.07–0.085 (0.18–0.20/0.075–0.09), tibia 0.175–0.205/0.055–0.06 (0.17–0.21/0.055–0.06), tarsus 0.195–0.235/0.045–0.05 (0.185–0.215/0.045; leg IV: trochanter 0.15–0.16/0.10–0.11 (0.15–0.185/095–0.11), basifemur 0.135–0.155/0.09–0.11 (0.135–0.16/0.09–0.11), telofemur 0.22–0.265/0.10–0.12 (0.22–0.255/0.095–0.115),

tibia 0.24–0.29/0.07–0.085 (0.235–0.295/0.07–0.075), tarsus 0.20–0.255/0.05–0.06 (0.22–0.26/0.05–0.06), distance of tarsal tactile seta from proximal margin 0.08–0.095 (0.07–0.10).

Tritonymph: colour paler than adults. Pedipalp: trochanter 1.65, femur 2.40, tibia 2.22, chela (with pedicel) 3.03, chela (without pedicel) 2.86, hand 1.51 times as long as broad. Fixed chelal finger with 7 trichobothria, moveable chelal finger with 3 trichobothria; *ist* and *sb* absent (Fig. 121). Serrula exterior of chelicera with 16 lamellae; galea as in adults. Carapace with 9 setae on posterior margin; 1.22 times as long as broad. Tergal chaetotaxy: 9: 7: 9: 10: 12: 10: 12: 11: 11: 8: 10: 2. Sternal chaetotaxy: 4: (1)4(1): (2)6(2): 15: 14: 13: 14: 15: 13: 7: 2. Coxal chaetotaxy: 8: 8: 9: 12. Monotarsate.

Dimensions (mm): body length 1.14; pedipalps: trochanter 0.19/0.115, femur 0.30/0.125, tibia 0.30/0.135, chela (with pedicel) 0.53/0.175, chela (without pedicel) 0.50, moveable finger length 0.235, hand length 0.265; carapace 0.44/0.36.

Remarks. There is significant variation in characters that Beier (1951, 1953, 1957) considered were important delineaters at the specific level within the genus *Verrucachernes*. These include the number of internal accessory teeth on the chelal fingers. Examination of the Krakatau material reveals that it varies from possessing two teeth to completely lacking teeth, and indicates that this character must be discarded. Beier (1957) also placed great reliance on the number of blades in the cheliceral serrula exterior, but due to a certain amount of variation it too is discarded. Differences in surface sculpturing were cited as a specific character of *Microchernes orientalis*, but comparison of the types of this species and all of the other material at hand reveals that it does not differ at all. Thus, with all of these characters discarded and the lack of consistent differences in the size and shape of the pedipalpal segments leads me to synonymise *M. orientalis* and *M. insularis* with *V. oca*.

In the original description of *M. insularis*, Beier (1951) indicated the presence of two males and two females in the type series. However, only three specimens are present in the Basel collection, and the fourth specimen is not present in NHMW (Dr J. Gruber, pers. comm.). The alternative spelling of the localities of *M. orientalis* given in square brackets are modern spellings advocated by the US Board on Geographic Names and follows Harvey (1985).

Verrucachernes oca is widely distributed in the Oriental region from Vietnam to the Solomon Islands.

Smeringochernes Beier

Smeringochernes sp.

Material examined. Java. Ujung Kulon, Pulau Peucang, 6°45'S, 105°15'E, beating, 11 Sep 1985, 1 tritonymph (MZB, 62-16A, MH611.01, SL).

Remarks. Without adult material the identification of this species cannot be confirmed.

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THREE NEW UNUSUAL WATER MITES FROM AUSTRALIA (CHELICERATA: ACARINA: HYDRYPHANTIDAE, HYGROBATIDAE AND ATHIENEMANNIIDAE)

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Abstract

Harvey, M.S., 1988. Three new unusual water mites from Australia (Chelicerata: Acarina: Hydryphantidae, Hygrobatidae and Athienemanniidae). *Memoirs of the Museum of Victoria* 49: 355–361.

The following three new water mite taxa are described from south-eastern Australia. *Notopanisus vinnulus* sp. nov. (Hydryphantidae) from southern Tasmania; the genus was previously known only from southern South America. *Cookabates inermis* gen. et sp. nov. (Hygrobatidae) from Victoria and New South Wales; its closest relatives appear to be the "*Corticacarus*-like mites". *Mellamunda acares* gen. et sp. nov. (Athienemanniidae) from Victoria; it belongs to the previously monotypic subfamily Notomundamellinae.

Introduction

During recent years several new water mites have been collected from south-eastern Australia that represent either new genera or genera that have not yet been recorded from Australia. Three of these taxa are described below.

Specimens are lodged in the Museum of Victoria, Melbourne (NMV), Field Museum of Natural History, Chicago (FMNH) and the Canadian National Collection, Ottawa (CNC). Methods follow Harvey (1987).

Hydryphantidae

Notopanisus Besch

Notopanisus Besch, 1964: 92–Cook, 1974: 71-72 (Type species: *Notopanisus wetzeli* Besch, 1964, by original designation.)

Remarks. The genus *Notopanisus* was described by Besch (1964) for a single species, *N. wetzeli* Besch, which was collected in Valdivia Province, Chile and Rio Negro Province, Argentina. Cook (1980) subsequently collected a further specimen in Rio Negro Province. No other species of the genus have since been recorded in the literature, but during a recent field trip to Tasmania, a female belonging to the genus was recovered from interstitial waters at Little Florentine River, southern Tasmania. This site has already been shown by Cook (1986) to harbour many unusual and relictual water mites including *Australiothyas swaini* Cook, *Wandesia troma* Cook, *Australiotonia tolarda* Cook and *Guineaxonopsis australica* Cook. Although only a single female of *Notopanisus* was collected, it appeared that further material would not become available in the near future, so I have prepared this description to record the presence of the genus in Australia.

Besch (1964) noted small dorsalia in *N. wetzeli,* which was disclaimed by Cook (1974) who only recorded the presence of muscle attachment sites. The new species described below also lacks dorsalia.

Members of this genus appear to occur in heterogeneous microhabitats, as the holotype of *N. vinnulus* was taken from interstitial waters in a hole dug in a sandbar on the side of a creek, while all known specimens of *N. wetzeli* indicate its association with mosses (Besch, 1964, Cook, 1980).

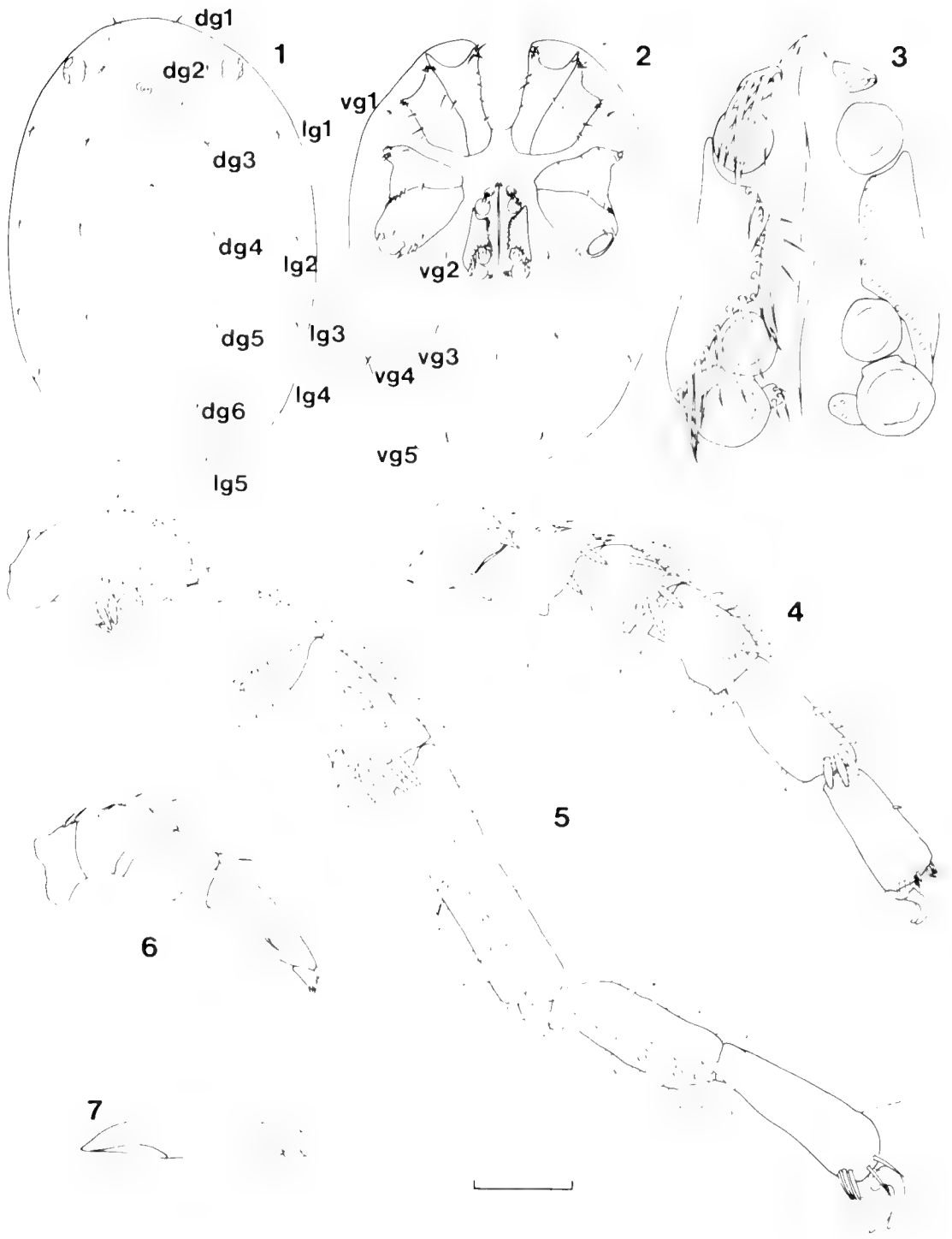
Notopanisus vinnulus sp. nov.

Figures 1–7

Type material. Holotype female, Little Florentine River, NE of Frodshams Pass, Tasmania, 42°14'S, 146°25'E, interstitial, M.S. Harvey and P.K. Lillywhite, 22 Nov 1986, NMV K745 (slide).

Diagnosis. lg4 anterior to dg6.

Description. Female: integument papillate. Lateral eyes on ocular tubercles; anterior-lateral eye about same size as posterior-lateral eye; postocularia slightly posterior to median eye, but well anterior to dg3; median eye with two dark eye-spots (Fig. 1). Six pairs of dorsoglandularia, five pairs of lateroglandularia and five pairs of ventroglan-



Figures 1–7. *Notopanisus vinnulus* sp. nov. Holotype female. Fig. 1, dorsal view. Fig. 2, ventral view. Fig. 3, genital field, setae on left side ommitted. Fig. 4, left leg I. Fig. 5, left leg IV. Fig. 6, left palp. Fig. 7, right chelicera. Scale line = 263 μm (Figs 1, 2), 66 μm (Fig. 3), 103 μm (Figs. 4–7).

dularia present (Figs 1, 2); sclerites associated with glandularia crescent shaped (Figs 1-2); vg3 slightly anterior to anus and vg4 but not approaching genital flaps (Fig. 2); anus only partially surrounded by faint sclerites. Genital field (Fig. 3) with a pair of small sclerites anterior to first pair of acetabula, with five stout setae; genital flaps with mesal row of stout setae, third pair of acetabula lying over posterior edge of genital flap; three pairs of ovoid acetabula, third pair largest and on short stalks. Chelicera (Fig. 7) slender, cheliceral claw curved, with 8 short teeth; cheliceral lamella over half as long as claw, serrate. Palp (Fig. 6): tibia with a thickened sub-distal seta on medial surface and with distal extension. Legs (Figs 4, 5) without swimming setae; leg IV with tibia and tarsus reflexed and with single simple seta on telofemur, genu, tibia and tarsus. Pedal claws without serrations or dorsal tooth (Figs 4, 5).

Dimensions (μm): body 1224/771; capitulum length 287; chelicera length 262; genital field 268/192; palp: trochanter 48, femur 106, genu 58, tibia 157, tarsus 45; leg I: trochanter 83, basifemur 109, telofemur 93, genu 109, tibia 147, tarsus 147/64; leg IV: trochanter 182, basifemur 152, telofemur 159, genu 288, tibia 173, tarsus 206/70.

Etymology. The specific epithet refers to the pleasure at finding a member of this genus in Australia (*vinnulus* Latin, delightful).

Remarks. This is the first member of the subfamily Thyasinae to be recorded from Australia, and it shows definite Gondwanan affinites. It differs from the only other described species of the genus, *N. wetzeli,* by the position of lg4 which is on approximately the same level as dg6 in *N. wetzeli,* yet is midway between the levels of dg5 and dg6 in *N. vinnulus.*

The paired spots of the median eye were observed and drawn before the specimen was cleared and slide mounted, but the pigment disappeared during the clearing process.

A map of the type locality was given by Jell and Stait (1985, fig. 1).

Hygrobatidae

Cookabates gen. nov.

Type species. Cookabates inermis sp. nov.

Diagnosis. Cookabates differs from all other hygrobatids in the form of the dorsal shield.

Description. Dorsal and ventral shields present; dorsal shield divided into 20 (♂) or 22 (♀) smaller platelets; 11 pairs of dorsoglandularia present; large antero-median plate bearing the postocularia. Genital field with 6 (♂), 7-9 (♀) pairs of acetabula (one or two are sometimes lost, or added); genital slit elongate, not heart-shaped. Palp: femur without ventral projection; tibia without ventral projection and mesal enlarged seta, usually without peg-like seta, but occasionally a very small seta is present. Tibia I without down-turned seta. Swimming setae absent.

Etymology. This genus is named for Prof. David Cook, in honour of his contributions to the taxonomy of Hydracarina, and is masculine in gender.

Remarks. The affinities of this genus are somewhat difficult to determine. The form of the dorsal shield, including 11 pairs of dorsoglandularia, indicate a relationship with *Corticacarus* Lundblad and its relatives which were united by Cook (1983) under "the *Corticacarus*—like mites". *Cookabates* lacks several character states and is thus distinctive:

(1) ventral projection of palpal femur absent; five genera of the group lack this projection (*Motasia* Lundblad, *Neocorticacarus* Lundblad, *Stylohygrobates* K. Viets, *Zelandobates* Hopkins and *Zelandobatella* Hopkins), as well as some species of *Corticacarus* (Cook, 1974, 1983).

(2) ventral projection of palpal tibia absent; only *Motasia* completely lacks this projection (Cook, 1974).

Interestingly, *Cookabates inermis* is similar to several described species of *Corticacarus* that further confuse the picture. *Corticacarus multiporus* Lundblad from Colombia is also polyacetabulate, but differs in possessing characters typical of *Corticacarus* (e.g. palpal modifications, and heart-shaped male gonopore) (Lundblad, 1953). The slit shaped openings of the dorsoglandularia of *C. inermis* resemble those of *Corticacarus cramerae* Cook and *C. cooki* (Imamura) (Cook, 1986).

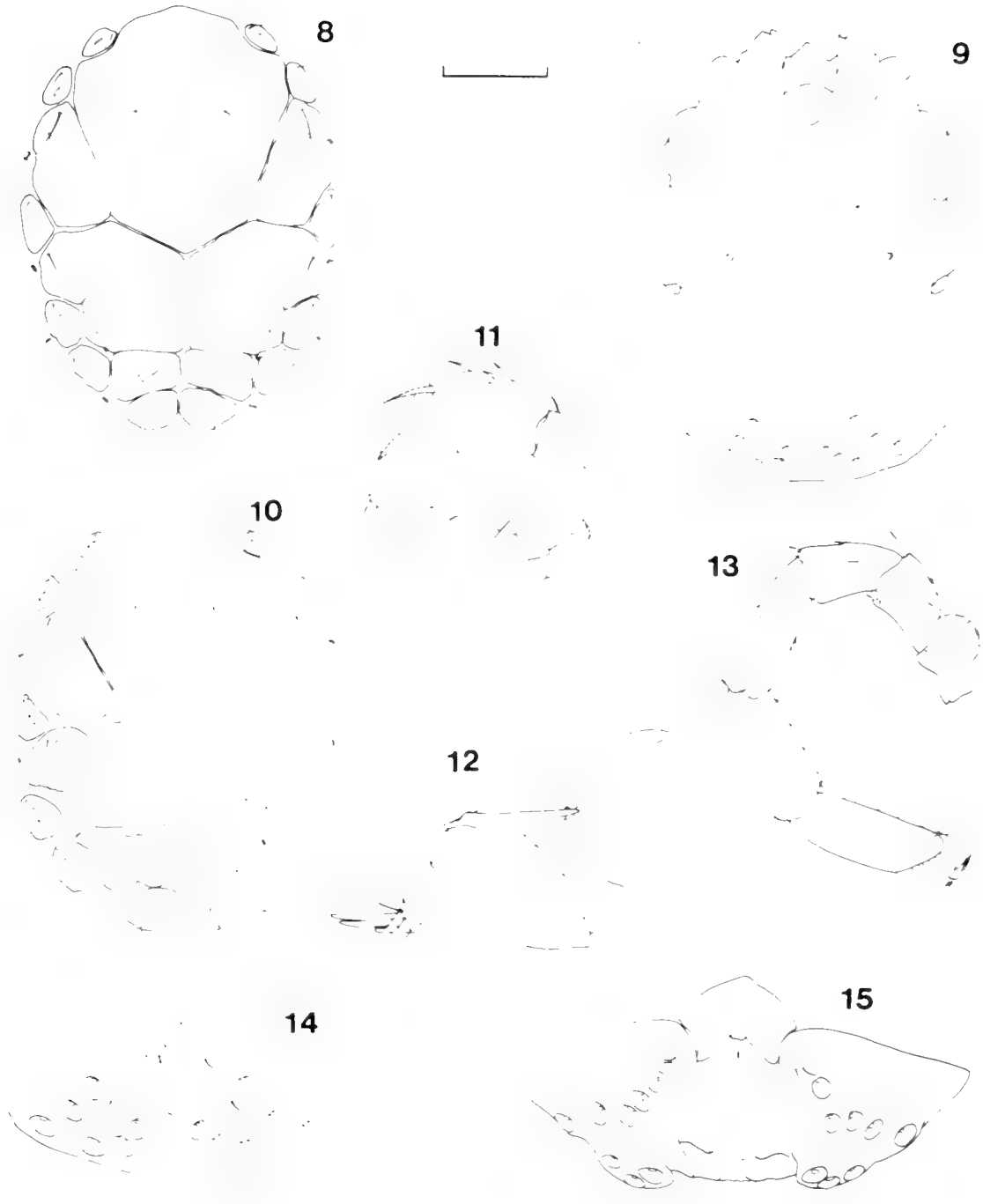
Cookabates inermis sp. nov.

Figures 8–15

Types. Holotype male, Taggerty River, 4.5 km ENE of Marysville, Victoria, 29 Apr 1985, P.S. Lake and R. St Clair, NMV K794 (slide).

Paratypes: Victoria: 1 male, 2 females, same data, NMV K795-797 (slides); 1 male, 1 female, same data, FMNH (slides); 1 males, 3 females, Taggerty River, 3 km ENE of Marysville, 29 Apr 1985, P.S. Lake and R. St Clair, NMV K798-801 (1 male, 1 female in fluid, remainder on slides); 1 male, 1 female, same data, CNC (slides); 4 females, Whitehouse Creek, 8 km ENE of Marysville, 26 Nov 1985, P.S. Lake and R. St Clair, NMV K804-807 (slides).

New South Wales: 1 female, Thredbo River, 12 km downstream of Thredbo sewage works, Kosciusko National Park, 29 Jan 1983, M.E. McKaige, NMV K808



Figures 8–15. *Cookabates inermis* sp. nov. Figs 8, 9, 12–14, holotype male. Figs 10, 11, 15, paratype female, K804. Fig. 8, dorsal shield. Fig. 9, ventral shield. Fig. 10, dorsal shield. Fig. 11, right palp. Fig. 12, capitulum, lateral view. Fig. 13, right leg 1. Fig. 14, genital field. Fig. 15, genital field. Scale line = 103 μm (Figs 8, 9), 143 μm (Fig. 10), 66 μm (Figs 11, 13, 14), 54 μm (Fig. 12), 92 μm (Fig. 92).

(slide); 2 males, Thredbo River, at Thredbo sewage works, Kosciusko National Park, 28 Jan 1983, M.F. McKaige, NMV K809-810 (slides); 1 male, same data except 22 Sep 1983, NMV K811 (fluid).

Other material examined. 1 male, Acheron River, 10 km N of Warburton, 18 March 1983, S. Schreiber, NMV (slide, dorsum lost).

Diagnosis. As for genus.

Description. Dorsal and ventral shields present; dorsal shield divided into 20 (♂), 22 (♀) platelets as in Figs. 8, 10, with 11 pairs of dorsoglandularia (most anterior pair incorporated into ventral shield and not figured), the openings of which are slit shaped; ventral shield entire, glandularia of fourth coxae slightly posterior to suture line between third and fourth coxae; capitulum with slightly down turned anterior extension (Fig. 12); genital field of male (Fig. 14) with 6 pairs of acetabula (occasionally reduced to 4 or 5), arranged in two diagonal rows of three; genital field of female (Fig. 15) with 7–9 pairs of acetabula (occasionally reduced to 6 or increased to 10), arranged in two groups. Palp (Fig. 11): femur and tibia without ventral projection; tibia usually without peg-like seta, but occasionally a small seta is present; tibia with two hair-like setae sub-distally. Legs: tibia I without downturned seta (Fig. 13); without swimming setae.

Dimensions (μm) male (female): dorsal shield 384–422/296–318 (467–489/370–461), large antero median plate 210–250/198–218 (237–288/240–300), ventral shield 424–454/333–346 (512–672/416–544); capitulum 103–115 (115–150); chelicera 186–214 (256–269); genital field plate width 225–237 (281–397); palp: trochanter 24–30 (32–35), femur 48–56 (65–81), genu 52–57 (72–83), tibia 72–80 (100–118), tarsus 35–37 (40–46); leg I: trochanter 56–64 (65–76), basifemur 49–73 (60–87), telofemur 67–70 (73–89), genu 90–101 (102–122), tibia 94–104 (104–121), tarsus 101–109 (108–120); leg IV: trochanter 84–99 (102–129), basifemur 60–70 (68–83), telofemur 78–95 (92–108), genu 115–128 (132–154), tibia 129–141 (152–186), tarsus 131–140 (136–161).

Etymology. The specific epithet refers to the lack of a ventral tubercle on the palpal femur and tibia (*inermus*, Latin, unarmed, defenceless).

Athienemanniidae

Mellamunda gen. nov.

Type species. Mellamunda acares sp. nov.

Diagnosis. Mellamunda is the only known water mite in which both males and females possess acetabula within the gonopore and incorporated into the ventral shield.

Description. Dorsal and ventral shields present; dorsal shield entire; with three pairs of dorsoglandularia; ventral shield with lateral carinae near third coxae. Genital field with 5 (♂), 8 (♀) pairs of acetabula lying within the gonopore, the opening of which in the male is crenulate, a further 9 (♂), 5–7 (♀) pairs in ventral shield. Palp: tibia greatly expanded and twisted inwards. Male genu III with distal lobed extension; leg IV not modified. Swimming setae absent.

Etymology. The generic name is derived from the European genus *Mundamella*, and is feminine.

Remarks. The Athienemannnidae is one of the smallest water mite families and contain only eight described species in five genera, *Mundamella* K. Viets, *Stygohydracarus* K. Viets, *Chelomudeopsis* K. Viets, *Phreatohydracarus* Tanasachi and Motas, and *Notomundamella* Cook (Cook, 1974, 1986). All except the last are included in the Athienemanninae; *Notomundamella* was recently described by Cook (1986) and placed in a separate subfamily, the Notomundamellinae. A further genus *Africasa* K. Viets, currently included in the Arrenuridae, may belong to the Athienemanniidae (Cook, 1986). The new genus and species described here has certain affinities with *Notomundamella*, but differs such that the definition of the subfamily must be altered as follows.

Revised diagnosis of Notomundamellinae. Males with acetabula lying within gonopore and incorporated into ventral shield. Females either with acetabula lying within gonopore (*Notomundamella*) or lying within gonopore and incorporated into ventral shield (*Mellamunda*). Male genu III with distal extension.

Mellamunda acares sp. nov.

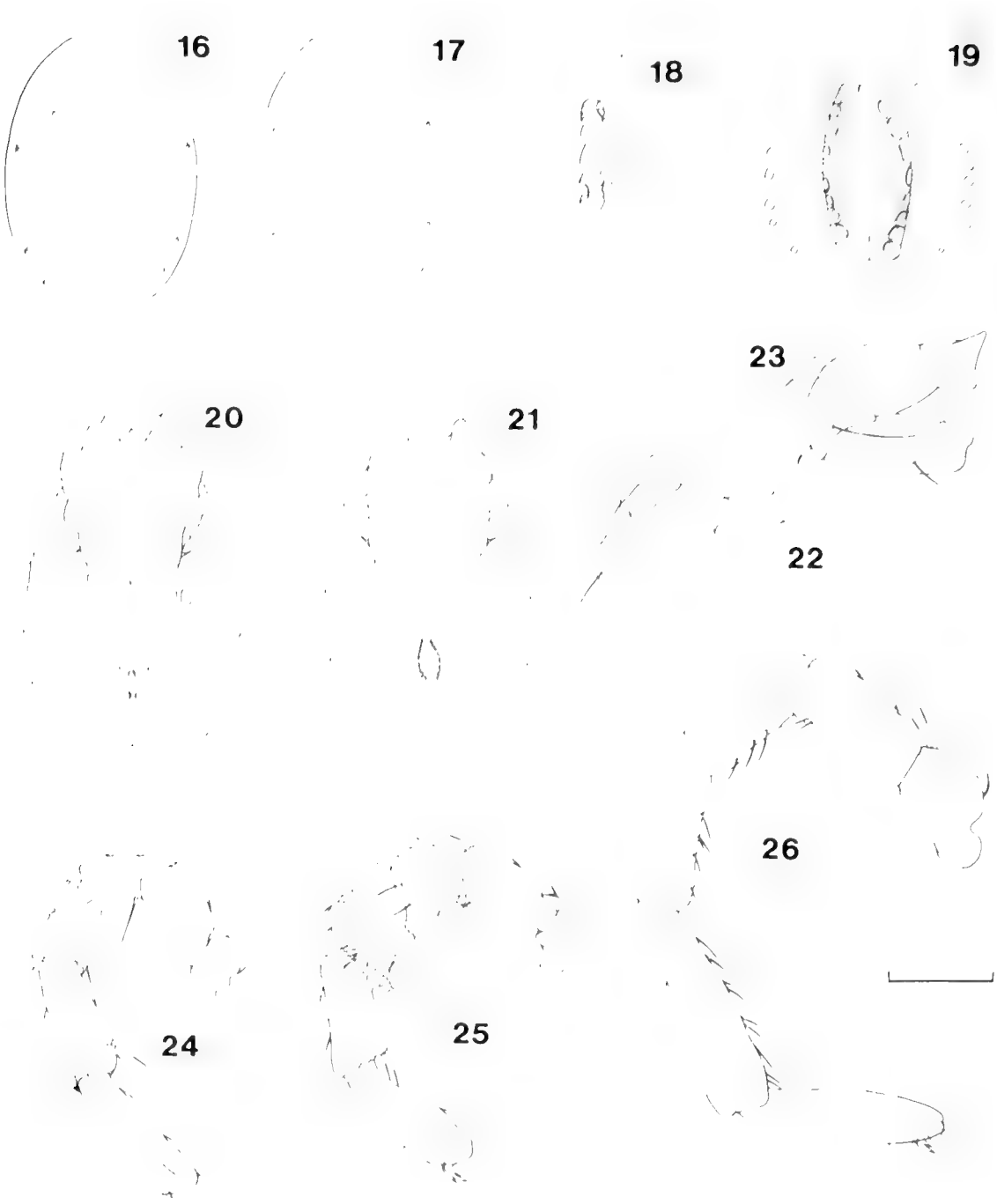
Figures 16–26

Types. Holotype male, Thomson River at Forestry Track C 6 (Thomson River Study site 12La), Victoria, 3 Mar 1981, collected by staff of Biological Survey Department, NMV K826 (slide).

Paratype: Victoria: 1 female, Thomson River, 7 km NNW of Walhalla, at Narrows Gauging Station (Thomson River Study site 11S), 3 Mar 1981, collected by staff of Biological Survey Department, NMV K827 (slide).

Diagnosis. As for genus.

Description. Dorsal and ventral shields present; dorsal shield entire (Figs 20, 21); three pairs of dorsoglandularia, posterior two pairs of male slightly closer together than those of female; postoculoria anterior to dorsoglandularia, those of female fur



Figures 16–26. *Mellamunda acares* sp. nov. Figs 16, 18, 20, 22–26, holotype male. Figs 17, 19, 21, paratype female. Fig. 16, dorsal shield. Fig. 17, dorsal shield. Fig. 18, genital field. Fig. 19, genital field. Fig. 20, ventral shield. Fig. 21, ventral shield. Fig. 22, capitulum, lateral view. Fig. 23, left palp. Fig. 24, left leg I. Fig. 25, left leg III. Fig. 26, right leg IV. Scale line = 177 μm (Figs 16, 17, 20, 21), 44 μm (Figs 18, 19, 22–23), 66 μm (Figs 24–26).

ther lateral than those of male; capitulum anteriorly acute in lateral view (Fig. 22); chelicera stout; anterior coxae extending beyond body proper; pair of glandularia present between genital field and fourth coxae; genital field of male (Fig. 18) with five pairs of acetabula within gonopore, plus a further nine pairs on ventral shield, margin of gonopore crenulate; genital field of female (Fig. 19) with eight pairs of acetabula within gonopore, plus a further 5–7 pairs on ventral shield. Palp (Fig. 23): genu with one long seta on external face; tibia enlarged and twisted. Legs (Figs 24–26): without swimming setae; male genu III with large ventral projection with three large setae on anterior face; male telofemur III with smaller ventral projection, without enlarged setae; male leg IV not modified.

Dimensions (μm) male (female): dorsal shield 486/331 (493/314), ventral shield 603/366 (582/384); capitulum 77 (110); chelicera 83 (?); genital field 50/10 (78/38); palp: trochanter 17 (19), femur 52 (62), genu 34 (41), tibia 60 (70), tarsus 13 (25); leg I: trochanter ? (51), basifemur 52 (58), telofemur 64 (58), genu 69 (66), tibia 90 (77), tarsus 102 (?); leg IV: trochanter 90 (70), basifemur 96 (77), telofemur 90 (70), genu 109 (97), tibia 160 (125), tarsus 138 (122).

Etymology. This species in named for its small size (*acares* Greek, small).

Remarks. The collection sites were discussed by Malipatil and Blyth (1982).

Acknowledgements

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A NEW SPECIES OF *LOBOHALACARUS* FROM AUSTRALIA (CHELICERATA: ACARINA: HALACARIDAE)

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Abstract

Harvey, M.S., 1988. A new species of *Lobohalacarus* from Australia (Chelicerata: Acarina: Halacaridae). *Memoirs of the Museum of Victoria* 49: 363-365.

The first known Australian member of the genus *Lobohalacarus*, *L. bunurong* sp. nov., is described from interstitial waters in the Thomson River, Victoria, and compared with other members of the genus.

Introduction

Freshwater members of the mite superfamily Halacaroidea have been collected infrquently in Australia. The only described species is *Astacopsiphagus parasiticus* K. Viets (Halacaridae). Recent collections with a freeze-corer in the Thomson River by members of the Museum of Victoria have contained a single specimen of the halacaroid genus *Lobohalacarus* K. Viets. While I fully realise the disadvantages of describing a new species on the basis of one specimen, it is considered desirable in this case for several reasons. Firstly, the genus *Lobohalacarus* has not been recorded from Australia before; previous known records are from Europe, Japan, USA, east Africa and South America. Secondly, the Museum of Victoria's large holdings of aquatic mites contains only a single representative of this genus and the likelihood of obtaining further specimens seems small. Thus I have prepared this description to record the genus from Australia for the first time.

The type is lodged in the Museum of Victoria, Melbourne (NMV), and is mounted on a microscope slide in glycerol gel. Terminology follows Newell (1984) except for the patella which is here referred to as the genu.

Halacaridae

Lobohalacarus K. Viets

Walterella Romijn and K.Viets, 1924: 215. Type species *Walterella weberi* Romijn and K. Viets, 1924, by monotypy. Preoccupied in Lepidoptera by *Walterella* Dyar, 1921.

Lobohalacarus K. Viets, 1939: 506. Replacement name for *Walterella* Romijn and K. Viets, 1924.

Diagnosis. Genua I and II approximately same size as telofemur and tibia. Ventral shield entire. Genital acetabula internal.

Remarks. Lobohalacarus belongs to a small group of halacarid genera in which the genua I and II are approximately the same length as the tibiae and telofemora. From the other genera of this group, *Lobohalacarus* may be distinguished as follows: from *Halacarus* Gosse and *Anomalohalacarus* Newell by the presence of a complete ventral shield, and from *Astacopsiphagus* by the lack of external genital acetabula.

The genus *Lobohalacarus* currently contains six species: *L. weberi* (Romijn and K. Viets) from Europe, east Africa, Japan and USA; *L. gallicus* (Migot) from France; *L. dolgarae* Green from England; *L. bucharensis* Jankowskaja from USSR; *L. processifer* (Walter) from Peru; and *L. hummelincki* K. Viets from Venezuela. The descriptions of *L. gallicus* and *L. dolgarae* (Migot, 1926; Angelier, 1952, 1965; Green, 1954) indicate that they possess short genua I and II and therefore that they most likely belong to another genus.

Lobohalacarus bunurong sp. nov.

Figures 1–6

Type material. Holotype female, Thomson River at Forestry Track C6 (Thomson River Study site T21a), Victoria, from frozen core sample 0–10 cm deep, 20 Mar 1986, R. Marchant, NMV K789 (slide).

Diagnosis. Palpal tibiotarsus with two sub-basal setae. Genital field with one pair of acetabula.

Description. Female: colour yellow-brown. Dorsum (Fig. 1) with four platelets, anterodorsal

Figures 1–6. *Lobohalacarus bunurong* sp. nov. Holotype female. Fig. 1, dorsal view. Fig. 2, ventral view. Fig. 3, right leg I. Fig. 4, right leg IV. Fig. 5, gnathosoma, lateral view. Fig. 6, left pedipalp. Scale line = 200 μm (Figs 1, 2), 135 μm (Figs 3–5), 74 μm (Fig. 6).

plate 0.91 times as long as broad, posterodorsal plate 1.54 times as long as broad, ocular plate 3.11 times as long as broad; setae not observed; anterior margin with long pointed process. Eyes absent. Ventral shield (Fig. 2) entire, with 8 pairs of setae, longest pair on coxa II. Epimeral pore situated at suture line between coxae I and II. Genital field with one pair of internal acetabula. Anal papillae without setae. Gnathosoma (Fig. 5) with elongate rostrum and one pair of tritorostral setae; chelicerae with long terminal claw. Pedipalps (Fig. 6) inserted laterally on gnathosoma; trochanter without setae; femur elongate with one sub-distal dorsal seta; genu with one stout medial seta; tibiotarsus with two sub-basal setae. Legs: carpite absent; median claw present, straight in legs I and II, curved in legs III and IV; lateral claws smooth in leg I, pectinate in legs II, III and IV; legs I and II with paired solenidia. Leg I (Fig. 3): thicker than other legs; basifemur and telofemur with long subbasal ventral setae; genu and tibia each with one pair of stout ventral and medio-ventral setae; tarsus with one slightly thickened medial seta. Leg II: tibia with two thickened ventral serrate setae. Leg III: tibia with one thickened ventral serrate seta. Leg IV (Fig. 4): tibia with two thickened ventral serrate setae.

Dimensions (μm): body 399/222; anterodorsal plate 106/116, posterodorsal plate 214/139, ocular plate 109/35; genital field 73/56; gnathosoma 111; chelicera 120; pedipalp: trochanter 14, femur 46, genu 11, tibiotarsus 35; leg I: trochanter 59, basifemur 49, telofemur 65, genu 67, tibia 72, tarsus 46; leg IV: trochanter 65, basifemur 30, telofemur 34, genu 46, tibia 66, tarsus 58.

Etymology. The specific epithet is derived from the name of the aboriginal tribe which originally inhabited the region including the type locality (Tindale, 1940), and is to be treated as a noun in apposition.

Remarks. This species differs from other members of the genus as follows: from *L. weberi* and *L. hummelincki* by the presence of only two setae (rather than three) on the palpal tibiotarsus; and from *L. gallicus* and *L. dolgarae* by the subequal telofemorae, genua and tibiae I (rather than genu I being shorter than telofemur I and tibia I). As stated above, the short genu I of *L. gallicus* and *L. dolgarae* indicates that these two species probably belong to another genus. Comparisons with *L. bucharensis* and *L. processifer* are not relevant at present because the only known specimens are nymphs and very little is known about ontogenetic changes in halacaroid mites, especially when comparisons between species are being made.

The holotype was taken from a core obtained by freezing the bed of the river as discussed by Marchant and Lillywhite (in press). The type locality was described by Malipatil and Blyth (1982).

Acknowledgements

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ARCHAEOGNATHA (INSECTA) FROM THE KRAKATAU ISLANDS AND THE SUNDA STRAIT AREA, INDONESIA

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Abstract

Sturm, H. and Bach de Roca, C., 1988. Archaeognatha (Insecta) from the Krakatau Islands and the Sunda Strait area, Indonesia. *Memoirs of the Museum of Victoria* 49: 367–383.

From the family Machilidae the genus *Graphitarsus* Silvestri, 1908 is redescribed and the species *G. sumatranus* newly described. The genus *Machilontus* Silvestri, 1912 family Meinertellidae and the species *Machilellus orientalis* Silvestri 1911, are redescribed, the species *Machilontus sumatranus* and *Macropsontus secundus* are newly described. The monotypic genus *Megalopsobis* Silvestri 1912, is considered to be a subgenus of *Machilontus* (new combination).

The phylogenetic relationships of the taxa mentioned and the zoogeographical importance of the material are discussed. The dispersal of eggs by drift material is considered as the most probable way of colonisation of the Krakataus.

Introduction

On the Zoological Expedition of La Trobe University to the Krakataus in 1984 eighteen specimens representing six genera of Archaeognatha were collected (Table 1).

Comparison of geographical distribution between the newly collected taxa and that of former collections from the three islands shows how incomplete our knowledge of the existing distribution was and probably still is. On each of the three islands a genus was newly discovered (Table 1).

Type material is located in: Instituto di Entomologia Agraria, Università degli Studi di Napoli, 80055 Portici, Italy (IEPA); Zoological Museum, Bogor, Indonesia (ZMB); and Museum of Victoria, Melbourne, Australia (NMV).

Machilidae

Graphitarsus Silvestri, 1908

Figures 1–17

Type species. Graphitarsus maindronii Silvestri, 1908: IEAP.

Redescription of genus. Relatively large, females reaching 15 mm body length. Dorsal curvature of thorax regular. Tergites, urosternites, head, head appendages, legs and abdominal styli with scales. Hypodermal pigment faintly developed, often indistinctly limited, more obvious on head.

Head. Frons between lateral ocelli strongly protruding. Eyes broader than long, line of contact at most equal to half length of eye. Lateral ocelli sole-shaped; median end wider and situated on frontal protrusion.

Maxillary palps. Without obvious sexual dimorphic characters.

Labial palps. Segment 3 in males and females distinctly widened, width of sensorial field nearly half of head width.

Legs. Relatively short and stout. Coxae II and III with markedly long styles, more than half coxal length. All tarsi with 3 segments, tips with paired scopulae of densely arranged, dark bristles normally S-shaped, with characteristic microstructure (fig. 9) very similar to that of scopula bristles of *Meinertellus*.

Urosternites. II–IX with stylets, I and V–VII or V–VI each with pair of coxal vesicles, II–IV each with 2 pairs. Sternites relatively large; length and width between third and half that of corresponding coxites.

Penis. Longer than half coxite IX, aedeagus nearly cylindrical, without specialized setae and with small terminal aperture. Urosternites VIII and IX with articulated parameres, markedly shorter than penis.

Ovipositors. Surpassing apices of stylets IX, of primary type. Distal third of ovipositors VIII with at least 4 macrochaetae on each segment.

Remarks. The validity of the closely related genus *Hybographitarsus* Paclt, 1969 from Java has yet to be proven. It differs from *Graphitarsus* by the extreme dorsal protrusion of the thorax, and from

Table 1. Collections of Archaeognatha on Java, Sumatra and the Krakataus

	Former collections	Krakatau Expedition,1984
Java	*Graphitarsus javanicus* Wygodzinsky, 1953, male	*Graphitarus* cf. *javanicus*, 1 male, Ujung-Gunung Payung
	Hybographitarsus zebu Paclt, 1969, female, Sukabumi	?*Hybographitarsus* sp., 1 juvenile, Ujung Kulon-Cibunar
	Machilellus orientalis Silvestri, 1911, female, Samarang *Machilontus javanicus* Silvestri, 1912, male, female, Nongkodjadjar	
		Macropsontus secundus n. sp., 1 male, 1 female, Ujung-Kulon-Cidaon *Macropsontus* sp., 1 female subadult, 2 juveniles, Ujung Kulon-Gunung Payung, Pulau Peucang, Cidaon
Sumatra	*Graphitarsus maindronii* Silvestri, 1908, female, Mts Médan	*Graphitarsus sumatranus* n. sp., 1 male, Liwa
		Graphitarsus sp., 1 female subadult, 1 juvenile, Liwa *Machilontus sumatranus* n. sp., 2 males, 2 females, Liwa *Machilontus* sp., 1 female subadult, Liwa
Krakatau (Rakata)	*Allomeinertellus jacobsoni* Silvestri, 1911, males, females	?*Allomeinertellus* sp., 1 juvenile, Owl Bay *Machilellus orientalis* Silvestri, 1911, 1 female, Zwarte Hoek

the also closely related genus *Metagraphitarus* Paclt, 1969 from Fernando Poo by the presence of coxal stylets on legs II. The genus *Graphitarsus* can be differentiated from remaining genera of Machilidae by the combination of the following characters: paired scopulae with setae of specific microstructure on the tips of all tarsi, median part of frons strongly protruding, median part of lateral ocelli markedly widened, particularly large coxal stylets on legs II and III, 2 pairs of coxal vesicles on each of the urocoxites II–IV. Dorsal curvature of the thorax as usual.

Key to species of *Graphitarsus*

(As parts of the species descriptions are incomplete the key can be only provisional.)

1 Urocoxites VII each with one coxal vesicle 2
— Urocoxites VII without coxal vesicles *G. maindronii* Silvestri, 1908 (Sumatra)
2 Length of setae on the ventral border of femur and tibia of all legs nearly attaining or surpassing the diameter of the corresponding segments (figs 6-8) 3
— Ventral setae on femur and tibia of all legs shorter than described above 4
3 Middle of scapus clearly pigmented; head pigment faint, more developed on frons ..... *G. surindicus* Bach, 1981 (India, Kerala)
— Middle of scapus faintly pigmented; head pigment around the base of antenna well developed (figs 1, 3) .. *G. sumatranus* sp. nov. (Sumatra)
4 Distance between inner borders of lateral ocelli shorter than 0.25 length of one ocellus. Dorsal half of frons only faintly pigmented .... *G. schmidi* Wygodzinsky, 1957 (Sri Lanka, Ratnapura)
— Distance between inner borders of lateral ocelli longer than 0.25 of one ocellus 5
5 Ratio length line of contact of the eyes: length of eyes less than 0.2 ... . *G. phillipsi* Wygodzinsky, 1957 (Sri Lanka, Horton Plains)
— Ratio line of contact/length of eyes greater than 0.2 .... *G. javanicus* Wygodzinsky, 1953 (Java)

Graphitarsus sumatranus sp. nov.

Figures 1–13

Material examined. Holotype female (11 mm); Sumatra, Barisan Selatan National Park, near Liwa; sweeping; 6 Sep 1984; ZMB.

Description. Body length 11 mm (female); maximum observed length of antenna 10.5 mm; caudal appendages broken. General colour of body yellowish; hypodermal pigment blackish-brown, generally faintly developed; more obvious on head, scapus and labial palps.

Head. Median part of frons strongly protruding and covered by semi-erect scales. Eyes broader than long with short line of contact. Lateral ocelli from black to redish brown, sole shaped, strongly approached. Hypodermal pigment concentrated near base of antenna (figs 1, 2). Width of eyes: width of head = 0.86. Length of eye: width of eye = 0.77. Line of contact: length of eye = 0.27. Distance between inner borders of lateral ocelli: length of ocellus less than 0.25. Distance between inner borders of lateral ocelli: width of head = 0.06.

Antennae. Scape nearly twice as long as broad, apically widened, the only segment with obvious pigmentation, preserved parts of flagellum with scales (fig. 3).

Maxillary palps. Segments 4–7 broken, once incompletely regenerated; dorsal process on segment 1 of median size, apical border with row of larger bristles (fig. 4).

Labial palps. Segment 2 somewhat broadened, apically with row of larger bristles; median border of segment 3 protruding. Pigment, see figure 5.

Legs. Relatively short and coarse, without distinct pigmentation. Coxal stylets very big and almost reaching length of coxae, pair II slightly curved. Ventral border of trochanter and more distal segments of all legs with many markedly long hyaline straight setae (figs 6–8). Bristles of scopulae slightly S-shaped with characteristic microstructure (fig. 9).

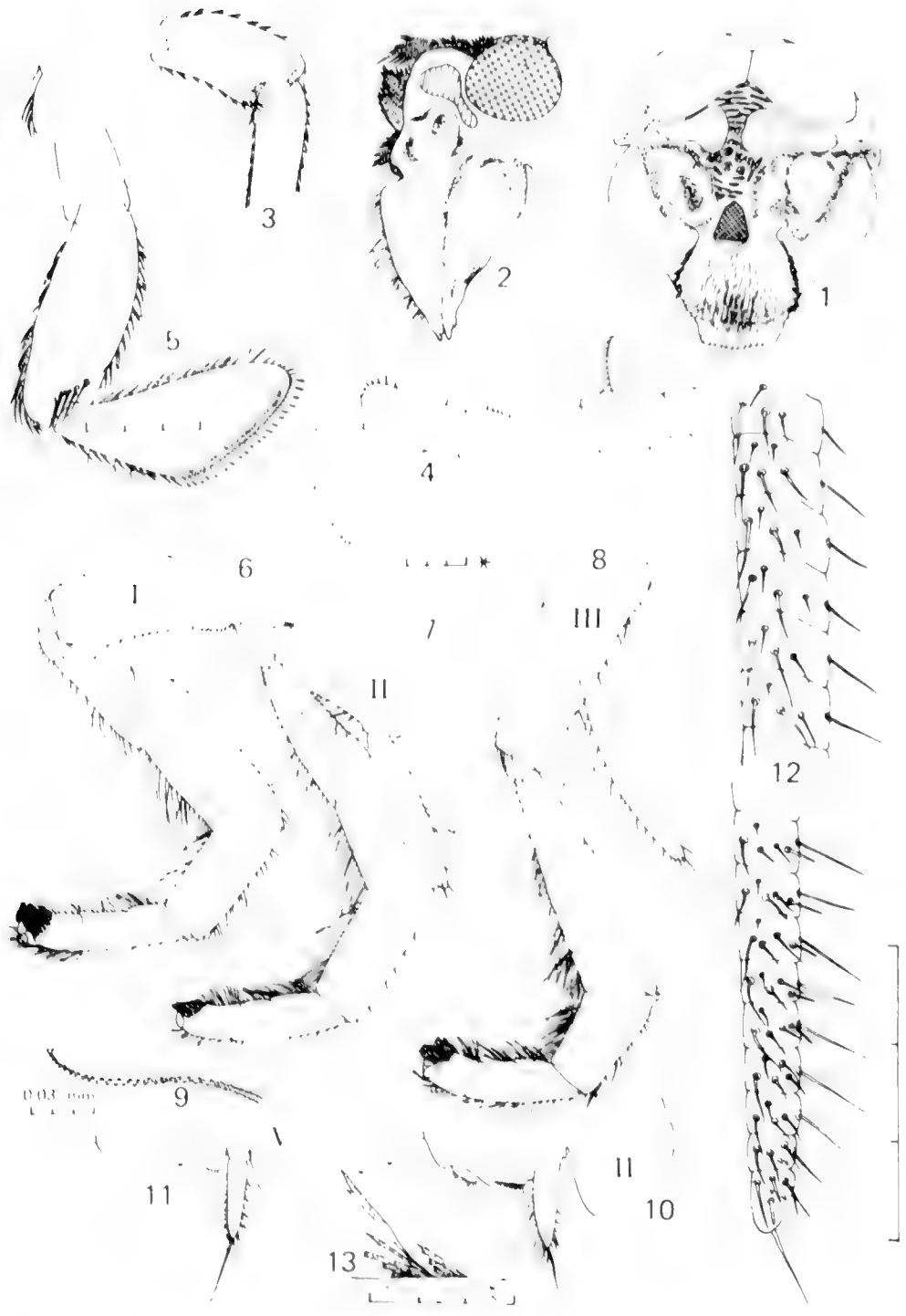
Urosternites. I and V–VII each with 1 pair of coxal vesicles, II–IV each with 2 pairs. Sternites relatively large, length and width more than one-third of that of corresponding coxites. Median angle of sternites II–V more than 90°, that of VI and VII more pointed. Stylets with hyaline bristles and long terminal setae (figs 10, 11). Convex curvature of inner border of stylet II obvious.

Ratio length of coxite: length of stylet: length of terminal spine for II = 2.3:1:0.5; for III = 2.3:1:0.5–0.6; for V = 2.6–2.8:1:1; for VIII = 1.6:1:0.64; for IX = 1.4:1:0.65.

Ovipositor. Nearly 2 mm longer than coxites IX. Distal half of ovipositor VIII with 5–7 long setae on each segment (fig. 12).

Caudal appendages. Terminal filament and median side of cerci with some more erect scales reaching 3 times length of normal scales (fig. 13).

Remarks. The species is close to *G. javanicus*. It differs from it in the lateral ocelli being closer



Figures 1–13. *Graphitarsus sumatranus* sp. nov., female 11 mm. (1) head, frontal view; (2) head, lateral view; (3) antenna, basal portion; (4) maxillary palp, lateral view, segments 4–7 regenerating; (5) labial palp, ventral view; (6–8) legs I–III; (9) hair of the scopula on higher magnification; (10, 11) urocoxites II and V, partly; (12) gonapophysis VIII, in part only: segments 1–9 and 33–38, counted from caudal; (13) scales of the terminal filament. Scale = 0.3 mm.

together, the denser and longer bristles on the ventral side of all legs, and the partly different ratios of the urocoxites and stylets. Differences from other species of the genus are mentioned in the key above.

Graphitarsus cf. **javanicus** Wygodzinksky, 1953

Figures 14–17

Material examined. Male 6.7 mm, Java, Ujung Kulon Gunung Payung, 480 m, 6°49'S, 105°16'E, beat, 21 Sep 1984; NMV.

Remarks. The characteristics of the specimen partly correspond to those given by Wygodzinsky (1953) for *G. javanicus*. The lack of pigment in the type specimen (collected in 1917) might be caused by bleaching. The differences in the ratios of eyes and stylets do not justify the description of a new species. Some characters which are important for comparison are mentioned here:

Hypodermal pigment on head, antennae and mandibles obvious.

Head. Scales on median protuberance of the frons less dense and less obvious. Ratio line of contact: eye length = 0.36. Eye length: eye width = 0.8. Distance of inner borders of ocelli: ocellus width = 0.33–0.5 (figs 14, 15).

Antennae. Pigment on scape and pedicel (fig. 16). Pigment of flagellum more concentrated on the proximal three-quarters of each chain, intermediate jointlets light.

Maxillary palps. Ratio length segment 7:6:5 = 1:0.78:0.93 (fig. 17).

Abdominal stylets. Stylets II with convex curvature of inner border (fig. 10). Length of terminal spines of II and III half that of corresponding stylets.

Graphitarsus sp.

Material examined. Sumatra, Barisan Selatan National Park, near Liwa, 700 m; beating in secondary forest; 1 Sep 1984; NMV: female subadult 5.5 mm; 1 juvenile 5 mm.

?**Hybographitarsus** sp.

Material examined. Java, Ujung Kulon, along track to Cibunar, beating; 20 Sep 1984; NMV: 1 juvenile 4.7 mm.

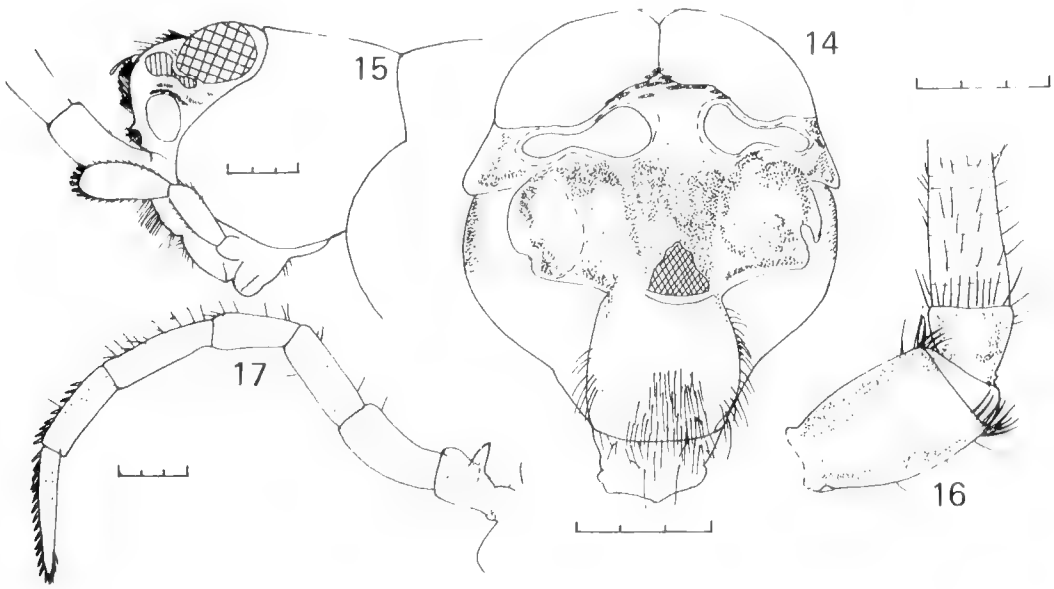
Remarks. The scopulae and the strongly protruded frons prove this to be a member of the *Graphitarsus*-group. The mesothorax distinctly more extruded than usual makes the genus *Hybographitarsus* probable.

Meinertellidae

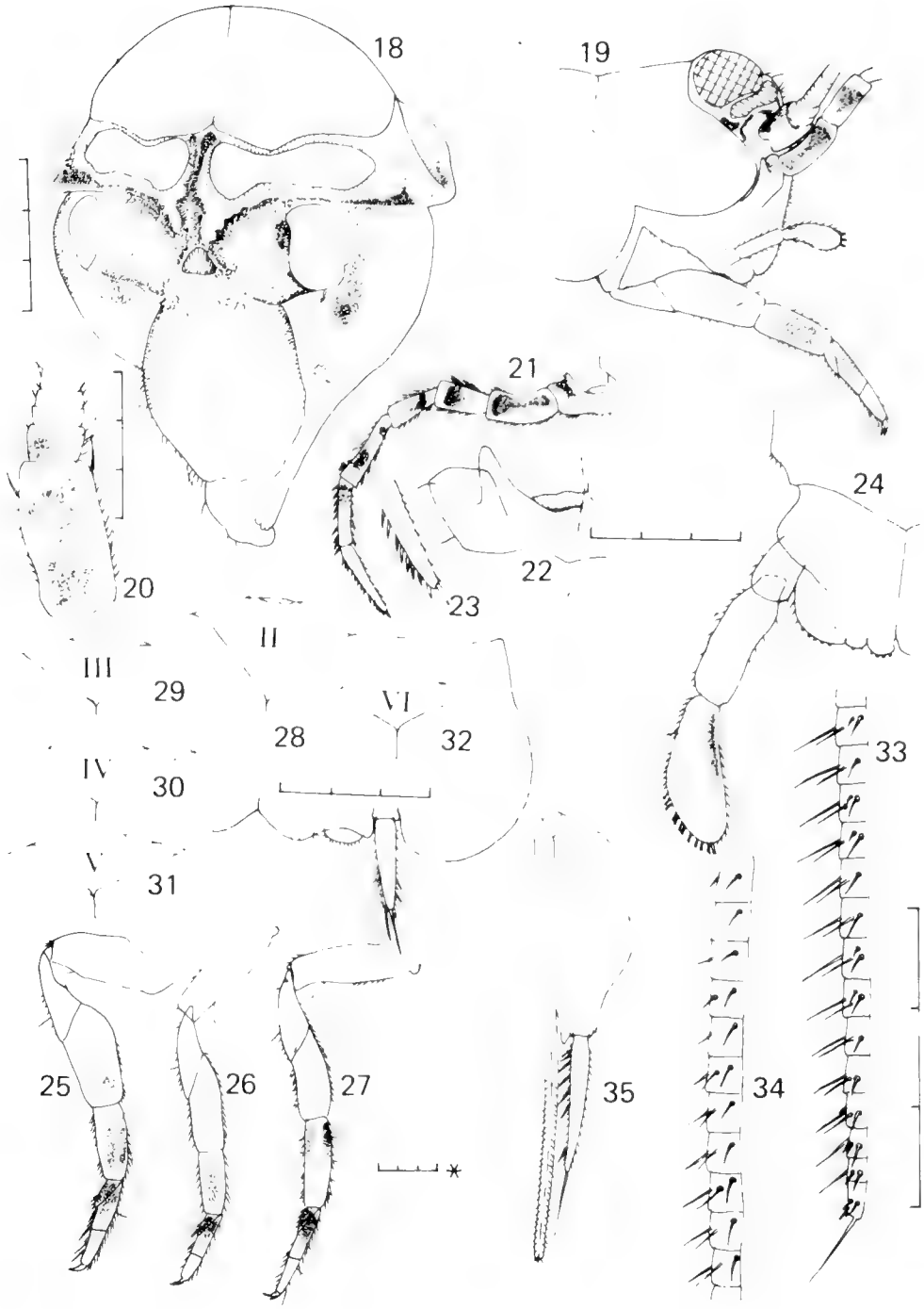
Machilellus orientalis Silvestri, 1911

Figures 18–38

Material examined. Java, Samarang; Ed Jacobson legit; IEAP: 1 female 5 mm. Krakatau Is., Rakata, Zwarte Hoek (6°09'S, 105°25'E), under bark of *Ficus* sp.; 12 Sep



Figures 14–17. *Graphitarus* cf. *javanicus* Wygodzinsky, 1953, male 6.7 mm. (14) head, frontal view; (15) head, lateral view; (16) antenna, basal portion; (17) maxillary palp, lateral view. Scale = 0.3 mm.



Figures 18–35. *Machilellus orientalis* Silvestri, 1911, female 6 mm. (18) head, frontal view; (19) head, lateral view; (20) antenna, basal portion; (21–23) maxillary palp, lateral view: survey, segment 1, apical portion of segment 7; (24) labial palp with part of labium, ventral view, (25–27) legs I–III; (28) urocoxite II; (29–32) urosternites III–VI; (33, 34) gonapophysis VIII, dorsal view; in part: segments 1–14 and 21–31, counted from caudal; (35) urocoxites and oviposotor IX, ventral view. Scale = 0.3 mm.

1984; NMV: female 6 mm.

Description. A very small species (maximum observed body length 6 mm). Colour of body light yellowish; hypodermal pigment dark purple, more developed on head, head appendages and legs.

Head. Frons not strongly protruded. Extensive pigment spots, a median stripe between eyes and clypeus and a V-figure between median ocellus and lateral ocelli more obvious. Eyes relatively large, width nearly three-quarters of head width; length and width of eyes nearly equal; ratio line of contact: length of eyes = 0.8. Lateral ocelli pigmented darkish red-brown, sole shaped, their width reaching 0.9 of eye width, close together medially: distance between inner borders some 0.14 ocellus length (figs 18, 19).

Antennae. 3.3 mm long (broken). Scape nearly twice as long as broad. Pigmentation see fig. 20. Segments of flagellum dark brown, only intermediate jointlets lighter.

Maxillary palps. Horizontal process on base well developed. Process on segment 1 relatively small; segments 1–6 with well limited pigment spots; segments 5–7 almost equal in length (figs 21–23, 36).

Labium. Submentum with blunted lateral corners. Segment 2 of palp with slight constriction on inner border; segment 3 distally somewhat broadened; pigmentation see fig. 24.

Legs. Without coxal stylets. Shape and bristles without specialisation. Pigmentation see figs 25–27 and 37. (In contrast to type specimen, coxae of Krakatau specimen are unpigmented.)

Urosternites. Width of sternite II reaching almost one-third of coxite width, median angle less than 90°; the other sternites are less wide, their median angle more than 90°. Coxites II–IX each with 1 pair of stylets, I–VII each with 1 pair of coxal vesicles. Stylets with well-developed terminal spines. Inner border of stylets II not obviously protruded but with 1–3 long and strong bristles reaching nearly the length of terminal spine. Ratio length of stylet: length terminal spine for II and IX = c. 0.5; for V = c. 0.75; for the rest = 0.6–0.7.

Ovipositor. Of primary type, surpassing terminal spines of stylets IX; gonapophyses VIII with 55–60 segments, distal half with longer setae, in distal third at least 3 macrochaetae on each segment except the terminal one.

Caudal appendages. Terminal filament 5.2 mm (broken). Cerci 3 mm, with simple terminal spines.

Remarks. As the former descriptions were incomplete or combined erroneously, a redescription was necessary.

The specimen described here fits very well the description of Silvestri (1911) based on a specimen from Samarang (Java). Silvestri did not mention the pigmentation of the holotype of *M. orientalis* but reexamination of the type material proved that our specimen is very similar to it. Wygodzinsky's (1953) specimen from East-Sumba, attributed to this species has very different pigmentation and is probably a different species needing description. The genus therefore probably has three species.

M. orientalis differs from the species from Sumba by the stronger and differently distributed pigmentation and also by closer lateral ocelli. *M. heteropalpus* Mendes, 1981 from Vietnam has maxillary palps distinctly different in shape and pigmentation. It also has an excessively protruded mesothorax and a more protruded median part of the frons.

The genus *Machilellus* is probably not so closely related to *Neomachilellus* Wygodzinsky, 1953 as suggested by Wygodzinsky (1953), Bitsch (1963) and Mendes (1981). Similarities reflect either plesiomorphic characteristics of the Meinertellidae (form of lateral ocelli, distribution of coxal vesicles) or apomorphic losses which were apparently realised several times during the phylogeny of Machiloidea (absence of coxal stylets).

Among other characters the chaetotaxy of penis and ovipositor demonstrates that *Neomachilellus* is a much more derived genus. For the separation from other genera see Mendes (1981).

Machilontus Silvestri, 1912 comb. nov.

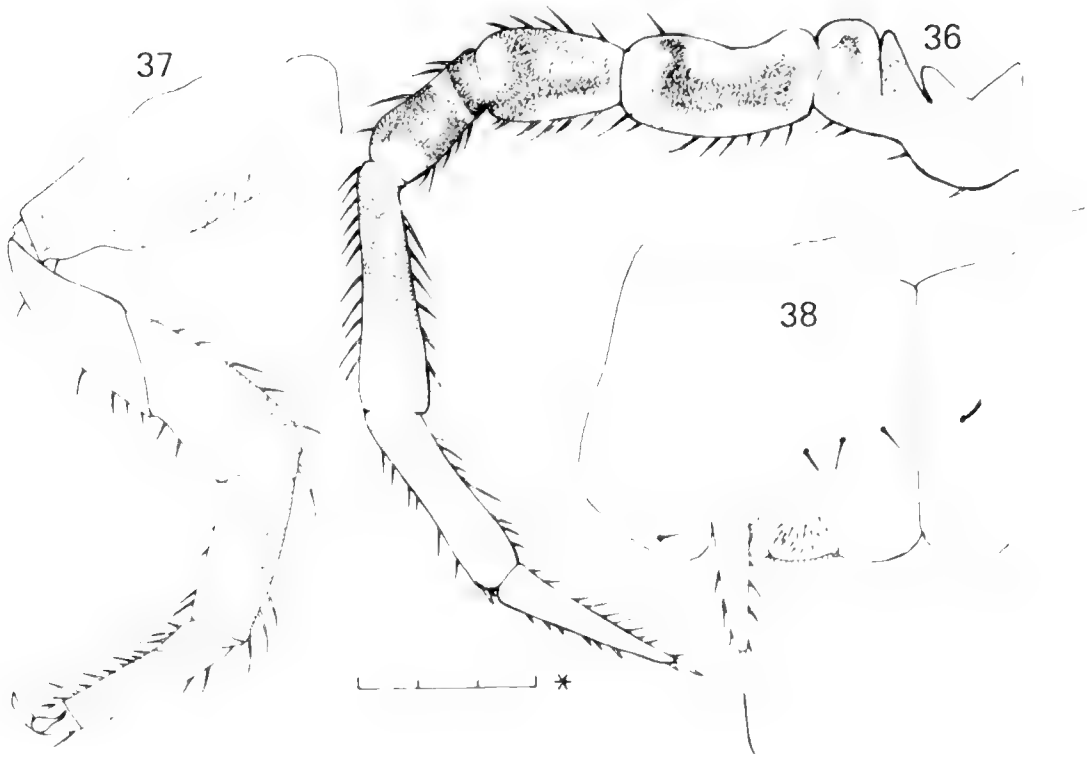
Machilontus Silvestri, 1912: 4–6.
Megalopsobius Silvestri, 1912: 3, 4.

Description. Of moderate length, maximum observed body length 11 mm. Body with scales except on head, head appendages legs and stylets. Hypodermal pigment faintly to strongly developed; on head, head appendages and legs mostly well defined.

Head. Eyes relatively large, width more than 0.8 of head width; ratio eye length: width = 0.8–1.4. Ratio length line of contact: eye length greater than 0.5. Lateral ocelli oblong, median part slightly or not constricted, length attaining 0.5–0.75 of eye width; distance of inner borders reaching 1.2 or more of ocellus length. Median part of frons sometimes somewhat protruded and with characteristic setae (compare figs 39 and 51).

Antennae. Unbroken longer than the body. Flagellum often with brownish pigment.

Maxillary palps. Horizontal process on basis well developed; dorsal process on segment 1 slightly to strongly protruded; segment 2 of male with hook-



Figures 36–38. *Machilellus orientalis* Silvestri, 1911, female type. (36) maxillary palp, lateral view; (37) leg III (?); (38) urosternite V. Scale 0.3 mm.

shaped process on distal-dorsal border longer than 0.5 of diameter of segment; process sclerotized with darker inner border; if process arises from separate cylindrical dorso-distally erected base this is shorter than 0.5 of hook length (fig. 60); position of hook between parallel and perpendicular to the longitudinal axis of segment (figs 40, 41, 60); ventral side of segment 5 in males may have many long straight setae.

Labium. Submentum laterally protruded. Distal part of segment 3 in males and females only slightly widened; inner border of segment 2 not obviously protruded (figs 42, 43, 61).

Legs. Relatively slender, only pair III with coxal stylets, length of which corresponds approximately to diameter of coxa (0.8–1.2x). All tarsi with only 2 segments (distal segment not subdivided). Ventral border of tibia I in males and females often with characteristic field of setae (fig. 45).

Urosternites. II–IX with stylets; I–VII each with 1 pair of coxal vesicles. Sternites relatively small, II largest but length and width not reaching one-third of corresponding values for coxites.

Ovipositor. Primary type, long and thin, surpassing stylets IX; distal part of gonapophyses VIII (0.5–0.6 of length) with 3–5 macrochaetae on each segment (fig. 57).

Penis. Short, no more than 0.7 of coxite length; aedeagus without specialised bristles, with slash-shaped ventral terminal aperture which is longer than 0.5 length of aedeagus (fig. 50).

Type species. Machilontus gravelyi Silvestri, 1912.

Remarks. The genus *Machilontus* described here also includes the monotypic genus *Megalopsobius* Silvestri, 1912. Examination of the preserved parts of the type species of *Megalopsobius, M. convergens* Silvestri, 1912: 4), from IEAP Museum showed no differences which could justify the maintenance of this genus. The name is reduced to a subgenus which is characterised in the following key. The genus *Macropsontus* is closely related to *Machilontus* and shares very large eyes and similar form and chaetotaxy of penis and ovipositor. The specific differences of *Macropsontus* are lack of coxal stylets on all legs and the longer cylindrical base of the hook of segment 2 of the male maxillary palp.

Key to *Machilontus* species

The three subspecies of *M. sutteri* described by Paclt (1969) are not included. Their descriptions are incomplete. In the descriptions of some other species important characters such as pigmentation pattern and some ratios are missing. So the key can be only provisional.

1 Hook of segment 2 of male maxillary palp with a well separated cylindrical base (fig. 60). Ratio eye length: width > 1.2 (Cerci longer than the body.) .... *M. (Megalopsobius) convergens* (Silvestri, 1912) (Burma/Thailand)

– Hook of segment 2 of male maxillary palp without well separated cylindrical base. Ratio eye length: eye width ≤ 1.2 .. *M. (Machilontus)* .. 2

2 Dorsal process on segment 1 of maxillary palps short, maximum length two-thirds of the diameter of distal portion of segment .... *M. gravelyi* Silvestri, 1912 (Burma/Thailand)

– Dorsal process of maxillary palp segment 1 larger than described above 3

3 Tibiae I on ventral side with a distinct field of many brownish bristles (fig. 45) 4

– Distinct field of bristles on fore tibiae lacking or only slightly developed ..... *M. javanicus* Silvestri, 1912 (Java)

4 Head with Y-shaped symmetrical pigmentation on frons. Median portion of frons protruded and with many short blackish bristles .... *M. lerang* Wygodzinsky, 1953 (Western Flores)

– Head without Y-shaped pigmentation and/or without field of short blackish bristles on frons 5

5 Legs without well defined pigment spots .... *M. lawrencei* Bach, 1981 (India)

– Legs with well limited pigment spots at least on femur and/or tibia . 6

6 Distinct spots of hypodermal pigment on all trochanters and coxae; segment 5 of maxillary palps without specialised setae .... *M. sumatranus* n. sp. (Sumatra)

– Hypodermal pigment on trochanters and coxae lacking; segment 5 of maxillary palp of male with many long setae on ventral side .... *M. sutteri* Wygodzinsky, 1953 (East Sumba)

Machilontus (Machilontus) sumatranus sp. nov.

Figures 39–59

Material examined. Sumatra, Barisan Selatan National Park, near Liwa, pitfall traps, 5-7-Sep 1984, ZMB: male 7.8 mm holotype, NMV: female 7.7 mm allotype (T-9621), 1 male (T-9622) and 1 female (T-9623) paratypes.

Description. Maximum observed body length 9 mm; colour pattern of eyes and pattern formed by scales unknown. Dark reddish brown hypodermal pigment on head, head appendages and legs conspicuous but not always well limited.

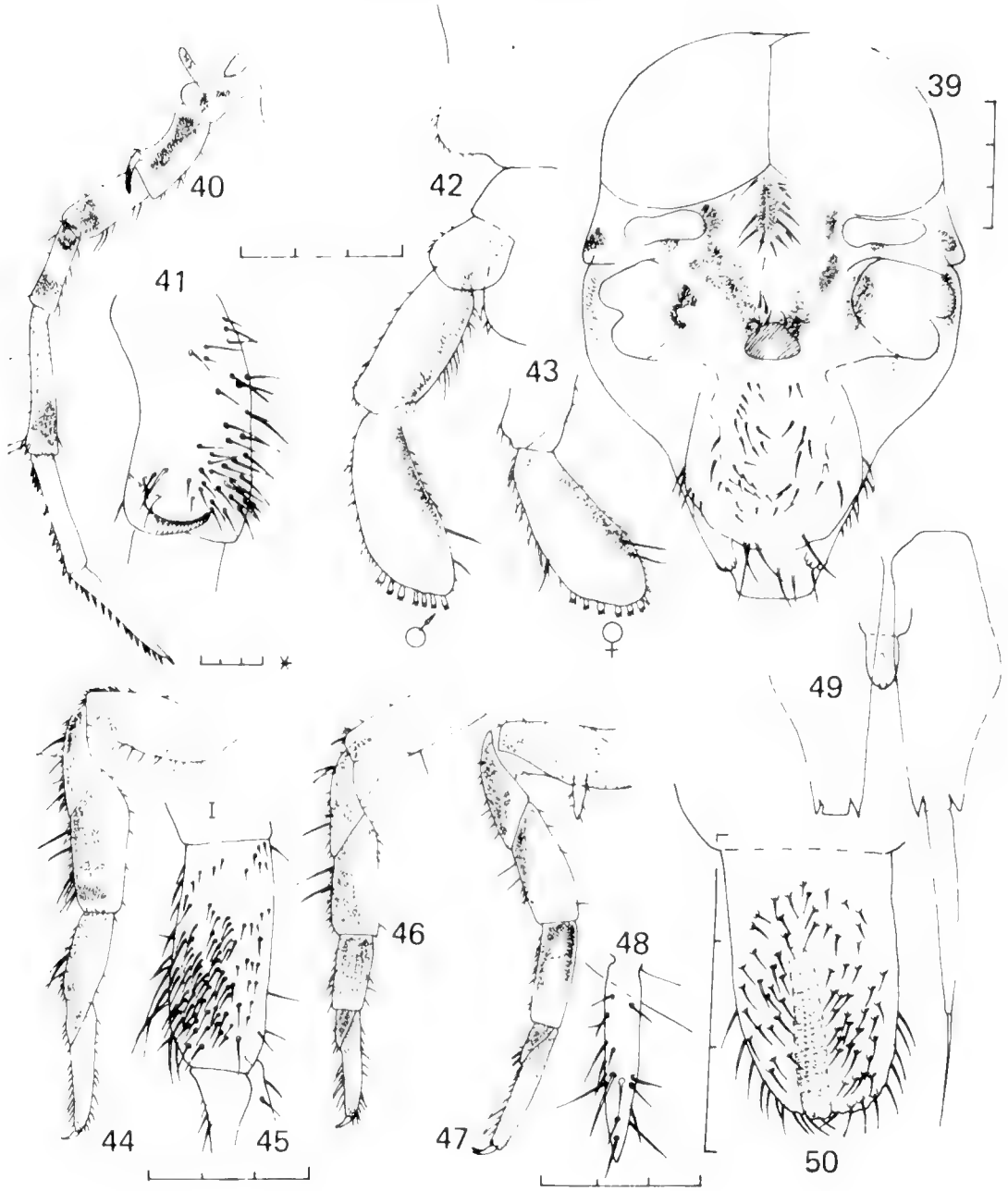
Head. Eyes large, width reaching approximately 0.9 of head width. Ratio eye length: eye width = 0.95–1.2. Line of contact: eye length = 0.65–0.75. Lateral ocelli in alcohol brownish grey to yellowish grey their length only half of eye width, distance between inner borders greater than ocellus length. Hypodermal pigment arranged in V-shape above the median ocellus, frons with median stripe of pigment, other spots around antennal base (fig. 39).

Mandible. With 4 teeth and pigment spots.

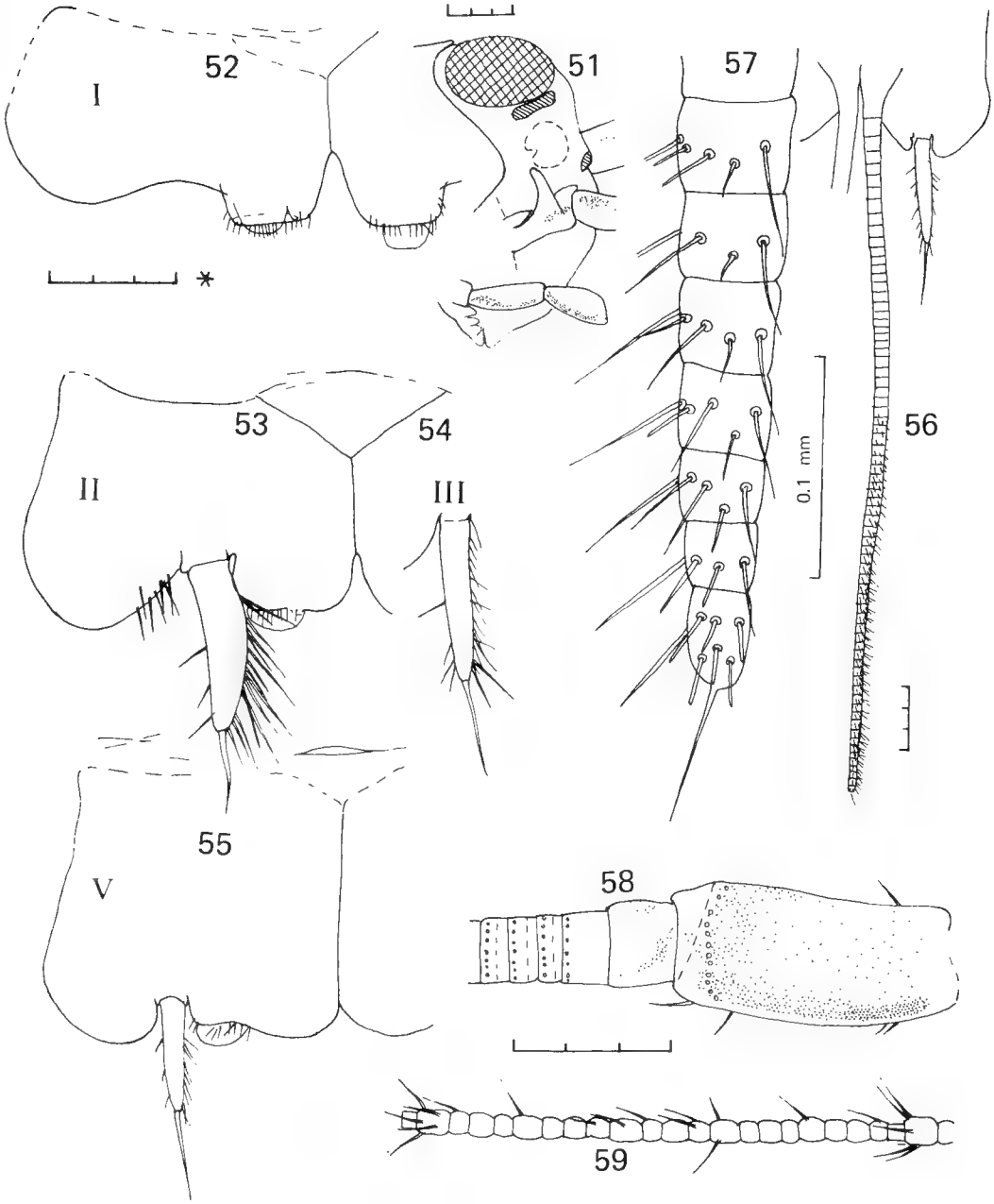
Antennae. Maximum observed length 10 mm; scape 2–2.5 times longer than broad. Pigmentation (fig. 58). Flagellum uniformly dark brown.

Maxillary palps. Dorsal process on segment 1 long and somewhat cylindrical, little longer than maximum diameter of segment. Hook on segment 2 of male typical for the subgenus, about as long as the diameter of segment 2 (fig. 41); segments 4–7 markedly thinner than those more proximal; segment 5 both in female and in male without special bristles. Ratio length of segments 7:6:5 = 1:1–1.05:1.2–1.25. Pigmentation (fig. 40).

Labium. Submentum laterally protruded; segment 3 of palpus in male and female only slightly protruded; inner borders of segment 2 and 3 with pigment stripe (figs 42, 43).



Figures 39–50. *Machilontus sumatranus* n. sp., males 7.8 and 8 mm, female 7.8 mm. (39) head, frontal view, male 8 mm; (40) maxillary palp, lateral view of inner side, male 8 mm; (41) maxillary palp, segment 2, with hook, lateral view, male 7.8 mm; (42, 43) labial palp, ventral view, male 8 mm and female 7.8 mm; (44, 45) leg I, male 8 mm: survey, tibia on higher magnification; (46) leg II, male 8 mm; (47) leg III, male 8 mm; (48) coxal stylet of leg III, male 7.8 mm; (49) urocoxite IX with penis, ventral view, male 8 mm; (50) penis, ventral view, male 8 mm. Scale = 0.3 mm.



Figures 51–59. *Machilontus sumatranus* n. sp., male 8 mm, female 7.8 mm. (51) head, lateral view, male; (52–55) urocoxites, ventral view, male, I, II, stylet III, V; (56, 57) gonapophysis VIII, ventral view: survey and terminal part; (58) antenna, basal portion, male; (59) antenna, flagellum c. 10 mm from the base, male. Scale = 0.3 mm.

Legs. Coxal stylets on pair III somewhat longer than maximum diameter of corresponding coxae and about 0.3 of coxal length. All segments of all pairs with pigment spots (figs 44, 46, 47). Tibia I with characteristic field of brownish bristles (fig. 45).

Urosternites. I–VII each with 1 pair of coxal vesicles, II–IX with stylets. Base of coxal vesicles I pro-

truded; sternite II relatively large; stylets II with conspicuous convex curvature of inner border, a small field of bristles lateral to stylet base. Coxites II, III, VIII and IX 1.3–1.8 times as long as the corresponding stylets, coxites IV–VII 1.9–2.5 times. Terminal spines II, III, VIII and IX 0.4–0.7 times as long as corresponding stylets, spines IV–VII 0.7–1.9 times as long (figs 52–55).

Penis. Reaching nearly half length of coxites IX, without specialised bristles, aperture forming median ventral fissure, sligthly longer than half aedeagus length (figs 49, 50).

Ovipositor. Of primary type, long and slender, surpassing stylets IX; gonapophyses VIII with long setae distally on more than half of length, gonapophyses IX on about 1/3; number of macrochaetae per segment on ovipositor VIII 4–5, on IX 3 (except for terminal segments) (figs 56, 57).

Caudal appendages. Broken, preserved parts without specialisation.

Remarks. The species can be separated from others by: legs with hypodermal pigment on all segments, characteristic pigment pattern on head and labial palps, field of specialised setae on tibiae I, lack of specialised setae on the ventral side of segment 5 of male maxillary palps, up to 5 macrochaetae on each of the distal segments of gonapophyses VIII. The specialised shape of urostylets II could not be compared with that of other species. The new species is perhaps related to *M. sutteri* although Wygodzinsky (1953) noted a lack of coxal vesicles VIII. This character needs to be verified.

Macropsontus secundus sp. nov.

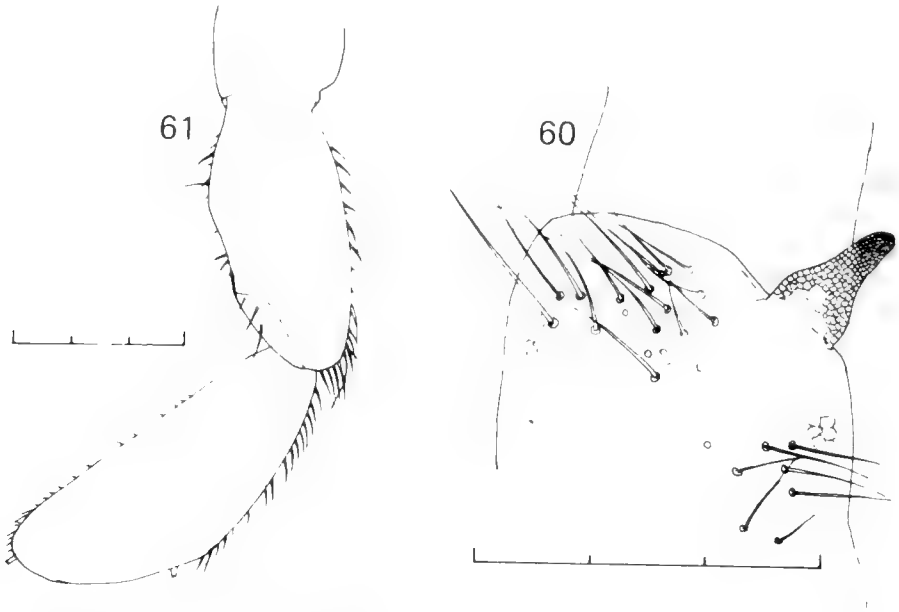
Figures 62–84

Material examined. Java, near Ujung Kulon Cidaon, 15 Sep 1984; ZMB: male 10.1 mm holotype; NMV: female 8.6 mm allotype (T-9624). Ujung Kulon-Gunung Payung, 300 m, beating, NMV: 1 female inadult.

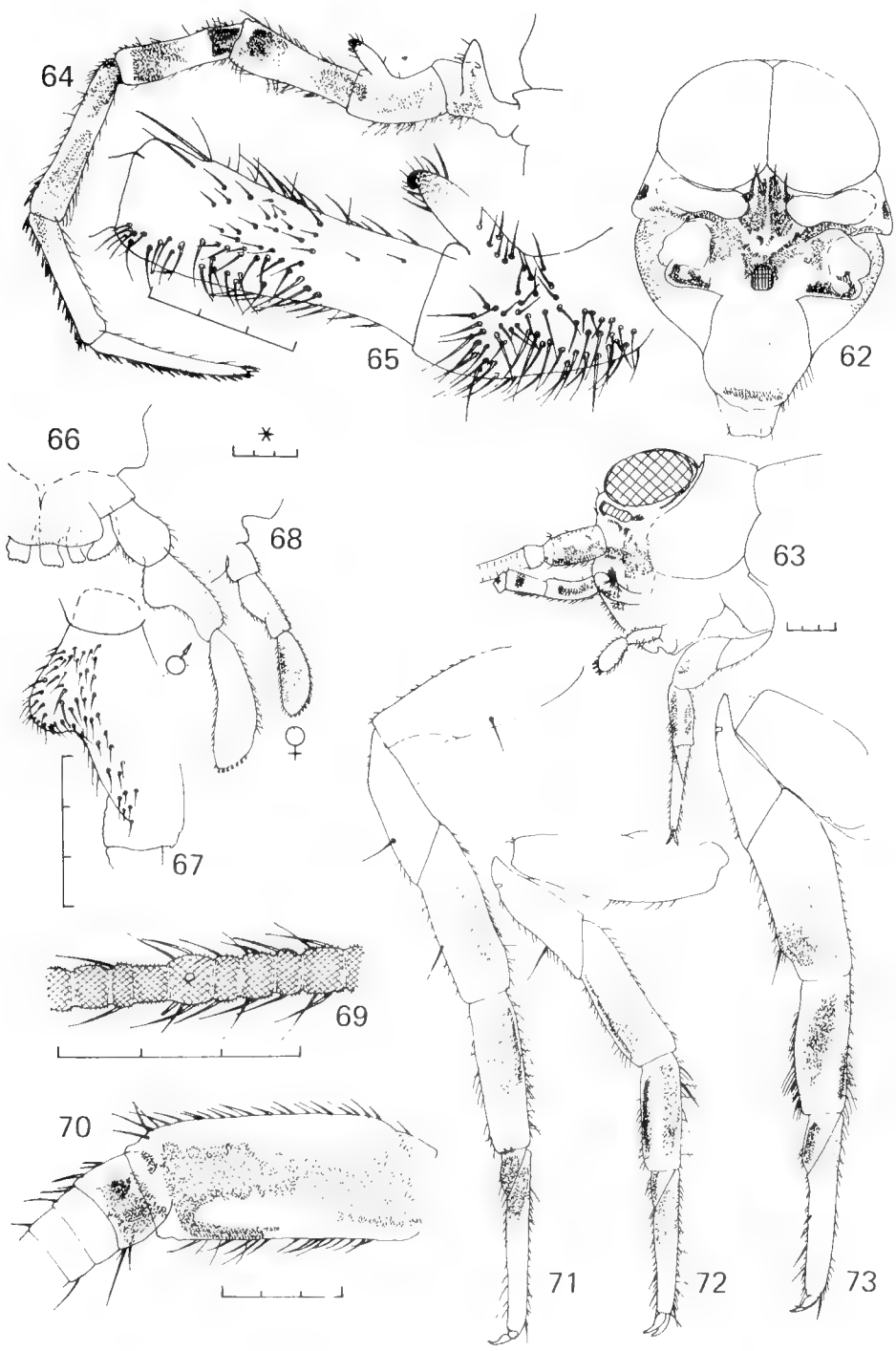
Description. Medium-sized animals (maximum observed body length 10.1 mm). Colour of eyes and scale pattern unknown. Head, head appendages, legs and stylets without scales. Hypodermal pigment on head, scape, mouthparts, legs and some tergites faintly to strongly developed.

Head. Eyes very large, width attaining more than 0.8 of head width; ratio length line of contact: eye length = 0.69–0.76, eye length: eye width = 1.08–1.2. Median part of frons sligthly protruding with some strong setae; lateral ocelli sole-shaped with slight constriction in median part; distance between inner borders smaller than half of ocellus length. Hypodermal pigment forming V-pattern above median ocellus and median spot between lateral ocelli (fig. 62).

Antennae. Maximal oberserved length 18 mm



Figures 60, 61. *Machilontus (Megalopsobius) convergens* Silvestri, 1912, male type. (60) maxillary palp, distal portion of segment 2 with hook, inner side; (61) labial palp, dorsal view. Scale = 0.3 mm.



Figures 62–73. *Macropsontus secundus* n. sp., male 10.1 mm. (62) head, frontal view; (63) head, lateral view; (64, 65) maxillary palp, lateral view, outside: survey segments 2 and 3; (66–68) labial palp, ventral view: survey male, segment 2 male, survey female; female 8.6 mm; (69, 70) antenna, distal portion of flagellum; basal portion; (71–73) legs I–III. Scale = 0.3 mm.

(male); scape 2.0–2.3 times as long as broad; proximal part of flagellum slightly annulated: segments dark brown, intermediate jointlets light brown; distal part uniformly dark brown. Pigment on scape and pedicel see fig. 70.

Mandible. With 4 teeth; pigment see fig. 62.

Maxillary palps. Horizontal process on base very short (apparently a generic character); dorsal process on segment 1 slightly triangular, little longer than distal diameter of segment. Distal-dorsal process on segment 2 of male with relatively long cylindrical base which turns distally to dark hook curved to median side (fig. 65). Specialised setae lacking in both sexes. Pigmentation see fig. 64. Ratio length of segments 7:6:5 – 1:0.85–0.93:1–1.1.

Labium. Sumentum with lateral protrusions. Segment 1 of palpus relatively long attaining more than half length of segment 2; inner border of segment 2 in male protruded, in female only slightly curved; segment 3 in both sexes slightly widened, distal sensorial field on male broader than that of female (figs 66–68).

Legs. All legs without coxal stylets; all tarsi with 2 segments; distal segment not subdivided (see remarks), relatively long and slender. Spots of hypodermal pigment on all tarsi, tibiae and femora; conspicuous fields of specialised setae missing; some short dark spine-like setae on the ventral sides of all tarsi combined with longer less pigmented transitional setae (figs 71–73).

Urosternites. I–VII each with 1 pair of coxal vesicles, vesicles small and those of each pair relatively far apart; II–IX with stylets; all sternites relatively small, sternite II largest, its width however not reaching more than one-third of breadth of corresponding coxites; median angle of all sternites greater than 90°; inner border of stylets II conspicuously convex, lateral to each base a small field of setae; coxites VIII of male protruding between stylet bases (fig. 78). Ratio length coxite: stylet length for IX 1.2–1.3, for II and III 1.5–1.6, for III–VII 1.7–2.1; ratio terminal spine length: stylet length for II and IX 0.25–0.35, for III–VIII 0.35–0.45 (figs 74–80).

Ovipositor. Of primary type, surpassing stylets IX, distal parts with long setae: on VIII half on IX c. 0.33–0.25 of total length; external setae per segment on the distal segments of VIII 4–5, of IX generally 3 (figs 81, 82).

Penis. Stout, only reaching half length of coxites IX; aperture a median ventral fissure which nearly reaches the length of aedeagus; setae near aperture somewhat shorter and broader (figs 83, 84).

Caudal appendages. Broken, without conspicuous characteristics.

Remarks. Macropsontus greeni Silvestri, 1911 from Sri Lanka was the only species of the genus previously known. Reexamination of the holotype (IEAP-Museum) proved that there are only two segments on all tarsi. In this point the description of the genus has to be revised. The new species differs from *M. greeni* in the proportions of the lateral ocelli, the longer cylindrical basis of the hook on segment 2 of male maxillary palps, the obviously protruded inner border of segment 2 of the male labial palps, and the pigmentation of maxillary palps, labial palps and legs (figs 85–93).

From the closely related genus *Machilontus* the genus can be separated by the lack of coxal stylets on legs III and the relatively long cylindrical base of the hook on segment 2 of the male maxillary palps. Its subgenus *Megalopsobius* is related to *Macropsontus* in the form of the hook-base on the maxillary palps of the male and the slight protrusion on segment 2 of the labial palps. *Macropsontus* is also related to *Hypomachiloides* in the tendency to protrusion on segment 2 of the labial palp, but *Hypomachiloides* has plesiomorphic tarsi with three segments.

Macropsontus sp.

Material examined. Java, Ujung Kulon, Gunung Payung (6°49'S, 105°16'E), 300 m, beating; 13 Sep 1984, NMV: female 5.4 mm (subadult). Ujung Kulon, Pulau Peucang (5°45'S, 105°15'E), beating, 11 Sep 1984, NMV: juvenile specimen, 3.4 mm (some characters correspond fairly well with those of the subadult female above). Ujung Kulon, Cidaon (6°46'S, 105°15'E), 22 Sep 1984, NMV: juvenile specimen, 3.1 mm, with scales (the colour patterns correspond fairly well with those of *M. secundus* from the same locality).

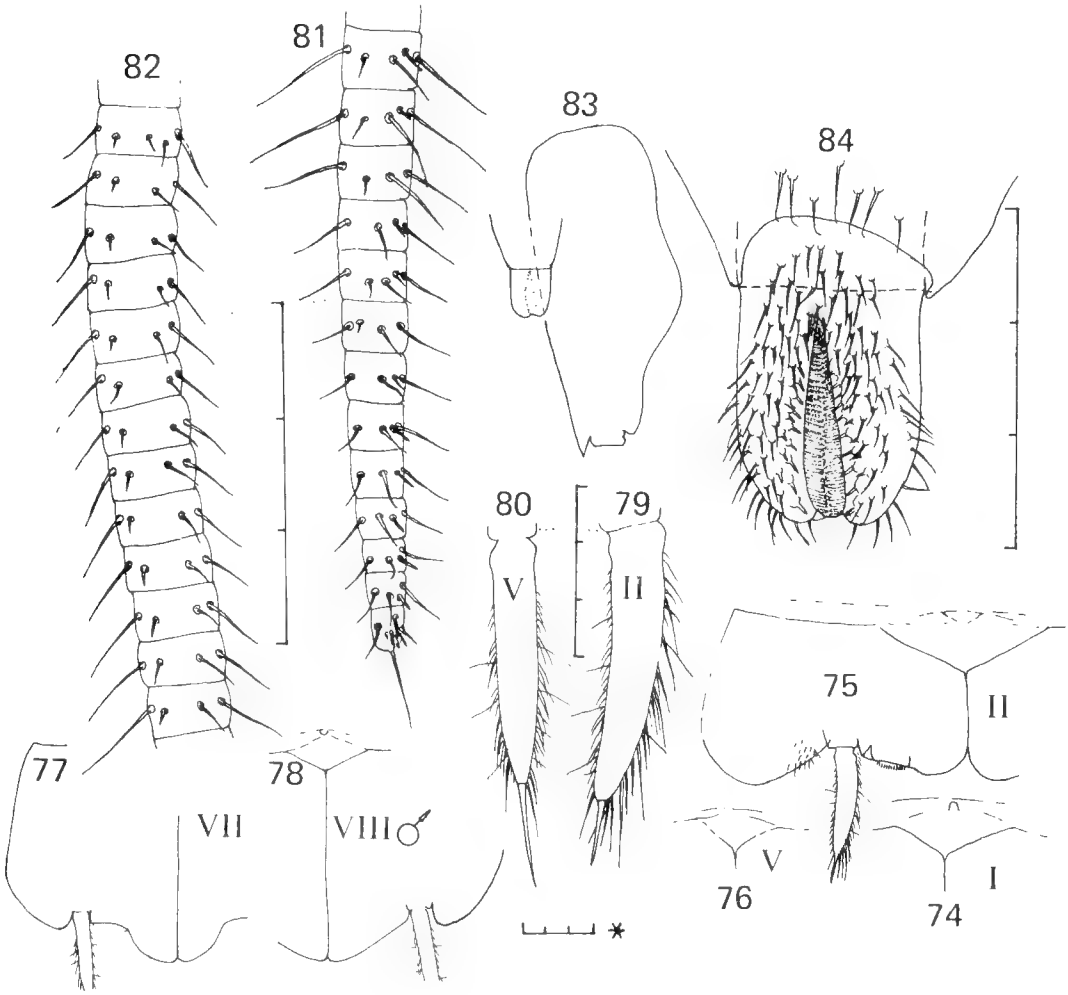
?Allomeinertellus sp.

Material examined. Krakatau Is., Rakata, Owl Bay (6°09'S, 105°28'E), 22 Sep 1984, NMV: juvenile specimen, 3.2 mm.

Remarks. Well developed scopulae on all tarsi. The barely protruded frons seems to indicate that it does not belong to the *Graphitarsus*-group. The only other genus with scopulae which was collected in this region and on the Krakataus is *Allomeinertellus*.

Discussion

The Machilidae, which have their centre of distribution in the northern hemisphere, reach Indonesia south of the equator with the genera *Graphitarsus* and *Hybographitarsus*. Its area of dis-



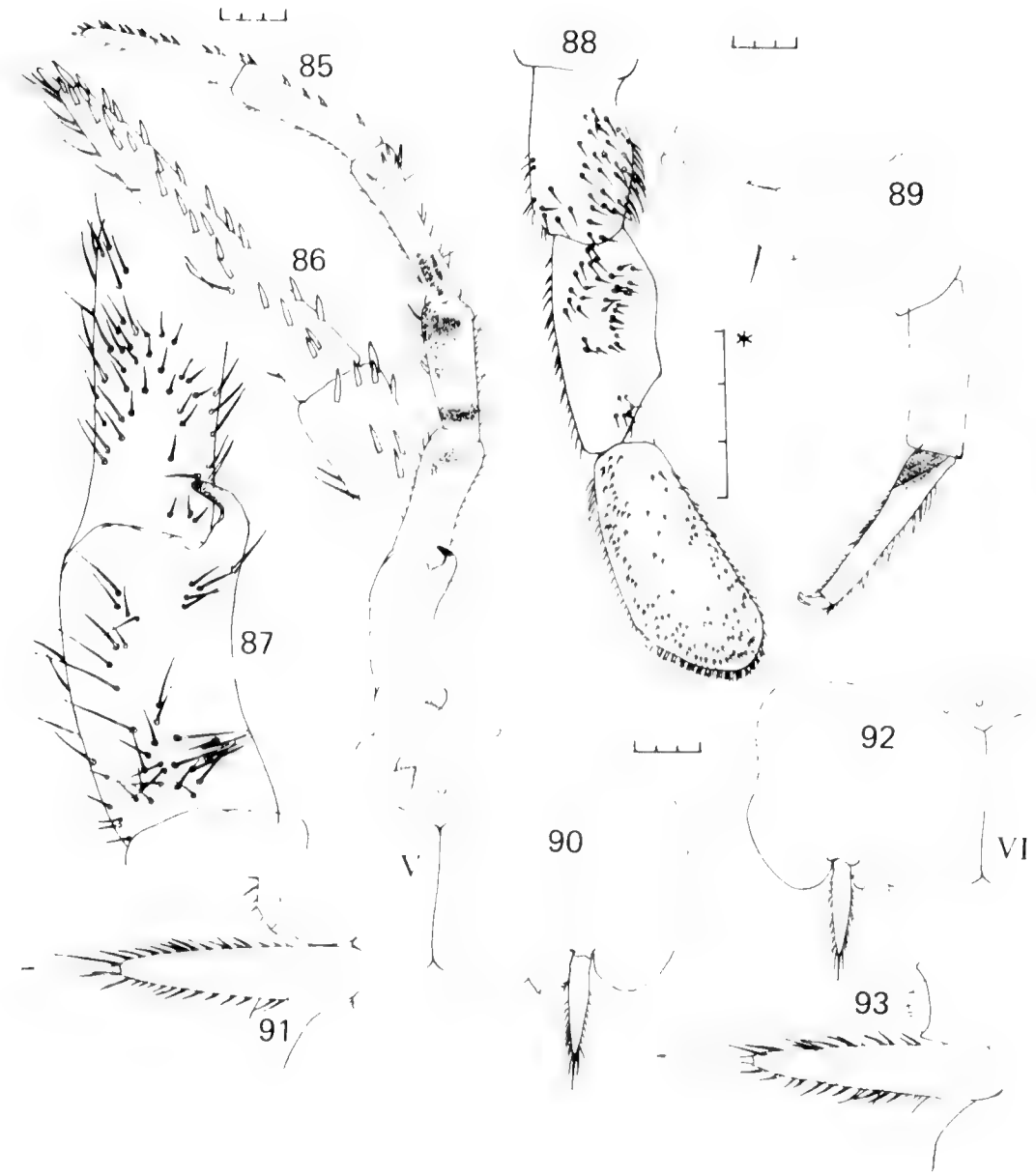
Figures 74–84. *Macropsontus secundus* n. sp., male 10.1 mm, female 8.6 mm. (74–77) urocoxites female I, II, V, VII; (78) urocxite VIII; (79, 80) stylets II, V, female; (81, 82) gonapophysis VIII, dorsal view, in part: segments 1–13 and 22–34, counted from caudal; (83) urocoxite IX with penis; (84) penis ventral view. Scale = 0.3 mm.

tribution overlaps here with that of the second and more derived family of Machiloidea, the Meinertellidae. Both genera reach the eastern limit of their distribution apparently on Java (Wygodzinsky, 1953; Paclt, 1969). The only indication of their existence on the Krakataus is a juvenile specimen with scopulae collected on this Island but it is more probable that it belongs to *Allomeinertellus* already described from there.

The Meinertellidae have their centre of distribution, except for the genus *Machilinus,* in the southern hemisphere. In the region of Farther India, Indonesia and Australia it has developed a centre of generic diversity with seven genera out of a total of 14 (Sturm, 1984). Of these seven genera, four had been previously recorded from Java, the Krakataus and Sumatra, the fifth was collected by the Krakatau expedition in 1984.

In view of the small number of specimens per genus in this region the chances of collecting new genera and species are high. For the same reasons definition of distribution does not seem advisable now.

Until now only two precisely identified genera of Archaeognatha, each with one species, have been collected on the Krakataus. One genus is known only from the Krakataus (*Allomeinertellus*). It must also exist elsewhere. The second genus and species,



Figures 85–93. *Macropsontus greeni* Silvestri, 1911, male type. (85–87) maxillary palp, inner side: survey, segment 7, segment 2 with hook; (88) labial palp, dorsal view; (89) leg III (?); (90) urocoxite V, part; (91) stylet V; (92) urocoxite VI; (93) stylet VI. Scale 0.3 mm.

(*Machilellus orientalis*) has also been taken at Samarang, Java (Silvestri, 1911).

Distribution of Archaeognatha is improbable by propagation through the air, by winds or hurricanes, because of their sensitivity (especially of young animals) to mechanical stress, their lack of wings, their size (body length of adults 6–15 mm), and the almost total absence of hurricanes in the Krakatau region. Transport on larger animals or directly by man is improbable because all members of the group react to any irritation by springing.

Dispersal of Archaeognatha through the ballast

of ships in historical times is probable for two species which deposit eggs on rocks, namely *Trigoniophthalmus alternatus* and *Petrobius brevistylis* (Wygodzinsky and Schmidt, 1980). For the Krakataus transport of eggs on rocks or wood by man's agency does not seem probable in spite of the fact that there has been some human contact with the Krakataus.

In this case the most probable way of dispersal is over water. On fresh water, adult Machilidae can survive several days (Sturm, 1984). Unfortunately experiments on sea water were not made. The eggs probably have a higher resistance to water. Larink (1972) stated that the egg blastoderm of two species of *Petrobius* is virtually impermeable even for fixing fluids. If one adds to this observation that many tropical species of Machiloidea probably lay their eggs on bark, wood and other vegetable matter and that the eggs of all species examined in this regard have a very long period of inner egg development, some more than 400 days (Larink, 1979), dispersal of eggs by drift-material on rivers and then by oceanic currents is perhaps the most probable way.

Moreover the purely volcanic Hawaiian islands possess a strongly specialised fauna of Machiloidea (Silvestri, 1904) which indicates a long period of isolated adaptation. Given the degree of specialisation, this must have begun much earlier than the arrival of man on the islands.

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We wish to express our gratitude to Prof. I.W.B. Thornton and Mr P. Vaughan (both from La Trobe University) who made it possible for us to examine this interesting material, and to Prof. E. Tremblay who placed at our disposal the type material of *Machilontus (Megalopsobius) convergens* Silvestri, 1912 and *Machilellus orientalis* Silvestri, 1911. Mr P. Vaughan and Dr G.C.B. Poore were so kind as to revise the English version of the manuscript.

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A REVIEW OF *ETEONE* SAVIGNY, 1820, *MYSTA* MALMGREN, 1865 AND *HYPERETEONE* BERGSTRÖM, 1914 (POLYCHAETA: PHYLLODOCIDAE)

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Abstract

Wilson, R.S. 1988. A review of *Eteone* Savigny, 1820, *Mysta* Malmgren, 1865 and *Hypereteone* Bergström, 1914 (Polychaeta: Phyllodocidae). *Memoirs of the Museum of Victoria* 49: 385–431.

Eteone sensu lato is reviewed and three genera recognised: *Hypereteone* Bergstrom, 1914 is resurrected and redefined; *Mysta* Malmgren, 1865 is retained unchanged and *Eteone* Savigny, 1820 is redefined to include all remaining species. *Hypereteone* now comprises nine nominal species including *H. otati* and *H. tingara* which are described as new species. An apparently undescribed species of *Hypereteone* is also recognised and *H. alba* (Webster, 1879), *H. barantollae* (Fauvel, 1932), *H. fauchaldi* (Kravitz and Jones, 1979), *H. foliosa* (Quatrefages, 1865), *H. heteropoda* (Hartman, 1951) and *H. lighti* (Hartman, 1936a) are proposed as new combinations. *Mysta* now includes seven nominal species and one undescribed form, and *M. platycephala* (Augener, 1913) is proposed as a new combination. *Eteone* sensu stricto now includes 28 nominal species of which four are designated *nomina dubia*. *Eteone palari* and *E. tulua* are described as new species. Keys are provided to distinguish the three genera and all well-described species within each genus. Australian species in all three genera are distinguished in a separate key.

Introduction

Phyllodocid polychaetes with two pairs of tentacular cirri on the first segment and lacking tentacular cirri on subsequent segments were placed by Bergström (1914) in three genera: *Eteone* Savigny, 1820 (species with setae and neuropodia on the first post-tentacular segment, proboscis lacking rows of papillae); *Mysta* Malmgren, 1865 (setae and neuropodia on first post-tentacular segment, proboscis with two lateral rows of large papillae); and *Hypereteone* Bergström, 1914 (first post-tentacular segment without setae or neuropodia, proboscis lacking rows of papillae). Most subsequent authors have retained *Mysta* as a distinct genus (Fauchald, 1977) or subgenus of *Eteone* (Uschakov, 1974; Hartmann-Schröder, 1971) whereas *Hypereteone* has been synonymised with *Eteone* by all authors except Hartmann-Schröder (1971).

In the course of this study I have arrived at a revised generic classification of species with only two pairs of tentacular cirri (on the first segment). I believe this arrangement best represents the natural relationships within the group. *Mysta* is retained as defined by Bergström, *Hypereteone* is revised to include all species with long tapered anal cirri, and *Eteone* sensu stricto contains all remaining species. In this scheme, although *Mysta* and *Hypereteone* appear to be monophyletic taxa, *Eteone* may be paraphyletic since it is characterised by absence of the characters which define related taxa (the heterogeneity of structures, particularly proboscis and setae, seen within species of *Eteone* is further indication that this genus does not represent a natural taxon).

The classification of the Phyllodocidae proposed by Bergström (1914) placed *Eteone*, *Hypereteone* and *Mysta* in the subfamily Eteoninae, together with *Pseudomystides* (which differs from the three genera treated here in having three pairs of tentacular cirri arranged on two segments) and *Pelagobia* (now placed in the family Lopadorhynchidae (Fauchald, 1977)). Bergström's subfamilial classification has been rejected by most recent authors (e.g. Uschakov, 1974) as not phylogenetically valid, however the three genera treated in this paper clearly represent a natural group, being defined by an arrangement of tentacular cirri which is unique in the family. The term *Eteone* genus-group is employed here for the convenience of referring to all three genera.

I have not attempted a strictly phylogenetic arrangement of genera and species, both because the material of many species is inadequate but also because present knowledge is such that it is not possible to carry out a cladistic analysis. (It is not clear which taxa would provide appropriate outgroup(s)

to establish character polarities, and as set out below, ontogenetic evidence appears to be uninformative in this family.) The following comments, which include a summary of the views of Uschakov (1974), are pertinent to this and future studies of the relationships of these genera. All authors agree that the degree of fusion and the number of appendages of anterior segments are of critical importance in arriving at a natural classification of genera. Bergström proposed that the evolutionary trend in the family was towards fusion of anterior segments and loss of aciculae, setae and tentacular cirri. The inference was that an additional anterior segment (carrying an additional pair of tentacular cirri) was present in the primitive form and that the *Eteone* genus-group represents an advanced condition, having lost the first segment and first pair of tentacular cirri, setae and aciculae from the second segment, and dorsal cirri from the third segment (of the primitive form). Bergström's views were based in part on anatomical study of the anterior nervous system; this appears to be a valid method of establishing homologies, however I have found it impossible to observe any detail of the nervous system in my dissections.

As set out fully by Wiley (1981), morphological change during ontogeny can be interpreted as passing through a series of plesiomorphic (primitive) character states prior to reaching the terminal derived condition. Thus Uschakov (1974) has noted that metatrochophore larvae of the *Eteone* genus-group already possess a single anterior segment with two pairs of tentacular cirri and inferred that this was the primitive condition. However, Nolte (1938) has published figures of larvae of several phyllodocid genera which invariably show that the arrangement of tentacular cirri found in adults is already present in metatrochophores. Similarly, Cazaux (1985) has described and figured the larval stages of *Mysta picta* from the Bay of Arachon (in the Bay of Biscay), showing that two pairs of tentacular cirri appear at the metatrochophore II stage (5 setigers) and that earlier larval stages lack tentacular cirri entirely. Cazaux also provided a table comparing larval development in *Phyllodoce*, *Eulalia* and *Eteone*; in each genus the adult condition appears at the metatrochophore II stage and no primitive arrangements of tentacular cirri are recognisable. Ontogenetic evidence, though arguably not sufficient in itself to establish character polarities (since neoteny cannot be excluded), nevertheless does not contribute to the debate as to which arrangement of tentacular cirri is the most primitive.

Uschakov's (1974) evolutionary scenario hypothesises a primitive phyllodocid in which all segments are similar; subsequently anterior segments one by one lost their setae and the dorsal and ventral cirri were transformed into long tentacular cirri. Finally, in some forms one or more anterior segments became fused and some tentacular cirri were lost. Thus the position of the *Eteone* genus-group could be primitive (having only the first segment modified, as suggested by Uschakov) or advanced (having been derived by fusion of anterior segments and loss of tentacular cirri from forms with several anterior segments modified, as proposed by Bergström). The question can only be resolved if the two pairs of tentacular cirri of the *Eteone* genus-group can be identified with homologous cirri in other genera, possibly through histological study of the nervous system.

Questions relating to phyllodocid phylogeny and the identity of poorly described species are unlikely to be fully resolved if only type material is studied. Carefully collected, narcotised and preserved specimens with probosces fully everted are required to adequately describe taxonomically important structures, especially in small specimens. This will be particularly important if histological techniques are utilised to aid study of the anterior nervous system.

Materials and methods

Morphological descriptions in this review generally recognise the importance of characters described by earlier workers. Two exceptions are the form of the anal cirri, which I consider to be of generic significance although description of anal cirri is omitted from many earlier descriptions; and the head of the setal shaft at the articulation of the blade, which provides characters which assist in distinguishing species. Where possible I have examined setae from the same specimen under both light microscope and scanning electron microscope (SEM). The setae are too small to resolve fine detail of the small teeth on the shaft (at the point of articulation with the blade) with light microscopy, however the setae are partly transparent under the light microscope and the useful specific character of the relative size of the large teeth (equal or unequal in size) is best observed in this way. SEM examination is essential if the fine structure is to be seen, but can wrongly indicate that only one large tooth is present unless coupled with light microscopy. SEM preparations for this paper are mostly from type material, thus only one or two parapodia could be removed for examination. Individual parapodia were subjected to ultrasonic cleaning for about 30 seconds before being air dried from 100% ethanol, mounted on stubs with

double-sided tape and gold coated before examination in a Philips SEM 505. The micrographs obtained by this method were variable and not always of publishable quality, however the critical structures could usually be seen clearly. Poor quality micrographs were used to trace line drawings and all figures of setae presented here were prepared in this way. The remaining figures were prepared with camera lucida attachments on stereo and compound microscopes. Location of all SEM stubs is given in the material examined sections of the species accounts.

There does not appear to be any significant variation in setal morphology from different parapodia, however due to the scarcity of material only the two most common Australian species, *Eteone palari* and *Mysta platycephala* have been examined in detail for such variation.

The shape of the dorsal cirri is useful in distinguishing many species. It is usually necessary to figure dorsal cirri for accurate descriptions, however in an attempt to standardise written descriptions the reader is referred to the following examples of descriptive terms for parapodial lobes used in this paper: ovoid, figs 2h, 4g; ovoid lanceolate, fig. 4b; lanceolate, fig. 5d; asymmetrical circular-ovoid, fig. 3d; rounded quadrangular, fig. 1d; trapezoid, fig. 2c; triangular acuminate, fig. 10d.

Since there is some intraspecific variability in the segment on which setae appear (in *Eteone spetsbergensis* and several species of *Hypereteone*), all descriptions use counts from the first segment (i.e. the segment carrying the tentacular cirri). Size and numbers of segments are given for the range of material examined; this information includes two width measurements in mm taken at segment 10: the first is body width excluding parapodia, and the second (in parentheses) including parapodia but excluding setae. Measurements were made with an eyepiece graticule on a stereo microscope; length of large specimens was simply measured against a mm scale. Width measurements of the anterior margin of the prostomium were taken between the points of insertion of the most dorsal pair of antennae. Left and right hand side parapodia are denoted LHS and RHS respectively.

The Australian material on which this study is based has come from several intensive benthic surveys of soft-sediment communities: Moreton Bay, Qld (Stephenson et al., 1974; Stephenson et al., 1976); NSW Shelf Benthic Survey (Jones, 1977); Bass Strait (Wilson and Poore, 1987); Port Phillip Bay and Western Port, Vic. (Poore, 1986); Northwest Shelf, WA (Australian Museum material, collected by CSIRO). All phyllodocids from all Australian state museums have also been examined; this material includes collections from a variety of other habitats, however species of *Eteone*, *Mysta* and *Hypereteone* were only encountered in soft-sediment collections. It is noteworthy that this group was not recorded from the intensive benthic survey of soft-sediment communities in Bass Strait cited above, although the most widespread species, *Mysta platycephala*, is common in nearby Port Phillip Bay.

It has not been possible to undertake an exhaustive search for types of all taxa, however type material of many species has been examined and these species are redescribed below. Where types have not been examined (either because there seemed little confusion as to the identity of the species or because the types were not available for study) a brief description taken from the most appropriate paper is included in the *Remarks* section of the species account. The following list summarises institution codes referred to hereafter:

AHF, Allan Hancock Foundation, University of Southern California, United States of America

AM, Australian Museum, Sydney, Australia

BMNH, British Museum (Natural History), London, England

HZM, Zoologisches Institut and Museum, Universität Hamburg, Hamburg, Federal Republic of Germany

MNHN, Muséum National d'Histoire Naturelle, Paris, France

NMV, Museum of Victoria, Melbourne, Australia

QM Queensland Museum, Brisbane, Australia

SMNH; Swedish Museum of Natural History, Stockholm, Sweden

USNM, National Museum of Natural History, Smithsonian Institution, Washington D.C., United States of America

WAM, Western Australian Museum, Perth, Australia

YPM, Peabody Museum of Natural History, Yale University, New Haven, Connecticut, United States of America

ZMO, Zoologisk Museum, Oslo, Norway.

The following list includes all species of *Eteone*, *Hypereteone* and *Mysta* recognised or synonymised in this paper. The list excludes many nominal species of *Eteone* and *Mysta* which have been moved to other genera by Hartman (1959, 1965). Questionable synonymies are discussed in the *Remarks* section of the supposed senior synonym. Genera and species in the systematic account are arranged in alphabetic order, except *nomina dubia* and other

poorly-known species which are listed separately in an Appendix.

aestuarina (Hartmann-Schröder, 1959); *Hypereteone*
alba (Webster, 1879); *Hypereteone*
andreapolis McIntosh, 1874; = *Eteone spetsbergensis*?
arctica Malmgren, 1867; = *Eteone longa*
armata Claparède, 1868; = *Mysta picta*?
balboensis Hartman, 1936a; *Eteone*
barantollae (Fauvel, 1932); *Hypereteone*
barbata (Malmgren, 1865); *Mysta*
bistriata Uschakov, 1953; = *Eteone spetsbergensis*
caeca Ehlers, 1874; = *Hypereteone foliosa*?
californica Hartman, 1936a; *Eteone*
cinerea Webster and Benedict, 1884; = *Eteone longa*?
columbiensis Kravitz and Jones, 1979; *Eteone*
crassifolia Ehlers, 1900; = *Eteone sculpta*?
cylindrica Ørsted, 1842; *Eteone nomen dubium* (see Appendix)
delta Wu and Chen, 1963; *Eteone*
depressa Malmgren, 1865; = *Eteone flava*
dilatae Hartman, 1936a; *Eteone*
fauchaldi (Kravitz and Jones, 1979); *Hypereteone*
filiformis Hartman-Schröder, 1980; *Eteone*
flava (Fabricius, 1780); *Eteone*
foliosa (Quatrefages, 1865); *Hypereteone*
fucata Sars, 1872; *Eteone*
geoffroyi (Audouin and Milne-Edwards, 1834); = *Mysta picta*?
heteropoda (Hartman, 1951); *Hypereteone*
incisa Saint-Joseph, 1888; = *Mysta picta*?
islandica Malmgren, 1867; = *Eteone longa*
japanensis McIntosh, 1901; *Eteone*
lactea (Claparède, 1868); *Hypereteone*, = *Hypereteone foliosa*?
lentigera Malmgren, 1967; = *Eteone flava*
leuckarti Malmgren, 1867; = *Eteone longa*
lighti (Hartman, 1936a); *Hypereteone*
lilljeborgi Malmgren, 1867; = *Eteone longa*
limicola Verrill, 1873; *Eteone*
longa (Fabricius, 1780); *Eteone*
maculata Ørsted, 1843; *Eteone nomen dubium* (see Appendix)
maculata Treadwell, 1920; *Mysta*
maculata Treadwell, 1922; JUNIOR HOMONYM, = *Eteone pacifica*
malmgreni Michaelsen, 1897; = *Hypereteone foliosa*?
ornata Grube, 1878; *Mysta*
otati sp. nov.; *Hypereteone*
pacifica Hartman, 1936b; *Eteone*
palari sp. nov.; *Eteone*
papillifera Théel, 1879; = *Mysta barbata*
picta (Quatrefages, 1865); *Mysta*
picta Ehlers, 1873; JUNIOR HOMONYM, = *Eteone spetsbergensis*?
platycephala (Augener, 1913); *Mysta*
pusilla Ørsted, 1843; *Eteone nomen dubium* (see Appendix)
reyi Gravier, 1906; = *Eteone sculpta*?
robertianae (McIntosh, 1874); *Eteone*
robusta Verrill, 1873; = *Eteone longa*
rubella Ehlers, 1900; = *Eteone sculpta*
sarsii Ørsted, 1843; = *Eteone flava*?
setosa Verrill, 1873; *Eteone nomen dubium* (see Appendix)
sculpta Ehlers, 1897; *Eteone*
spetsbergensis Malmgren, 1865; *Eteone*
spilotus Kravitz and Jones, 1979; *Eteone*
striata Bobretzky, 1868; = *Mysta picta*?
striata Levinsen, 1882; JUNIOR HOMONYM, = *Mysta picta*?
suecica Bergström, 1914; *Eteone*
syphodonta (delle Chiaje, 1822); *Mysta*
tchangsii Uschakov and Wu, 1959; *Mysta*
tetraopthalma Schmarda, 1861; *Eteone*
tingara sp. nov.; *Hypereteone*
tocantinensis Nolte, 1938; ?*Eteone* (see Appendix)
triangulifera Augener, 1913; *Mystides**
trilineata Webster and Benedict, 1887; *Eteone*
tuberculata Treadwell, 1922; *Eteone*
tulua sp. nov.; *Eteone*
villosa Levinsen, 1882; = *Eteone longa*?
vitiazi Uschakov, 1974; *Eteone*

**Eteone triangulifera* Augener, 1913 was referred to the genus *Mystides* by Augener (1924b) who believed that a third pair of tentacular cirri had been lost from the specimens. I have examined the type material of *E. triangulifera* Augener (HZM V-7904) which includes two specimens: one agrees with the original description of *E. triangulifera* and one is a species of Syllidae. Only three single tentacular cirri are now intact on the syntype and the typical prostomial pigmentation described by Augener (1913, 1924b) has faded. The minute size of the specimen, the almost circular prostomium with long threadlike antennae and the tentacular cirri which are swollen basally and taper to a long fine tip all indicate that this species should be placed in the genus *Mystides* as proposed by Augener (1924b).

Key to genera of Phyllodocidae with two pairs of tentacular cirri on the first segment

1. Anal cirri at least 5 times as long as width at base, tapering to a pointed tip; proboscis with 3 or more longitudinal rugose ridges or rows of low tuberculate papillae ..... *Hypereteone*
— Anal cirri digitiform or nearly spherical with blunt rounded tip, no more than 4 times as long as wide; proboscis not as above 2
2. Proboscis with 2 lateral longitudinal rows of foliose papillae and a dorsal band of very small denticulate papillae ..... *Mysta*
— Proboscis usually smooth basally, rugose distally, without longitudinal rows of papillae or numerous longitudinal rugose ridges (note: in the retracted position the proboscis may invert to produce a single longitudinal fold which is however absent when the proboscis is preserved in the everted position) ..... *Eteone*

Genus **Eteone** Savigny, 1820

Diagnosis. Phyllodocidae with 4 antennae, 2 pairs of tentacular cirri on the first segment. Second segment lacking dorsal cirri. Proboscis smooth and/or rugose, lacking longitudinal ridges or rows of papillae. Anal cirri short, globular to digitiform with rounded tips, no more than 4 times as long as wide.

Type species. Nereis flava Fabricius, 1780 (fide Hartman, 1959, original designation unknown).

Remarks. Eteone is defined here to exclude *Mysta* and *Hypereteone* and probably does not represent a natural group (see introductory comments above). At present *Eteone* contains a heterogeneous assortment of species including *E. filiformis*, *E. robertianae* and *E. tetraophthalma* which appear to be unlike all remaining species; the genus may need to be further divided when the phylogenetic relationships of the species become more clear.

Key to species of *Eteone*

Provision of a key to a genus where many species are poorly described or known from inadequate material demands compromise; the key excludes *nomina dubia* and the following species which appear to be distinct but could not be adequately described here: *E. balboensis* Hartman, 1936a; *E. fucata* M. Sars, 1872; *E. limicola* Verrill, 1873; *E. pacifica* Hartman, 1936b; *E. tetraophthalma* Schmarda, 1861; *E. tocantinensis* Nolte, 1938; *E. tuberculata* Treadwell, 1922; *E. vitiazi* Uschakov, 1974.

1. Prostomium and first segment wholly or partly fused; tentacular cirri narrow, threadlike 2
— Prostomium and first segment clearly delineated; tentacular cirri stout basally, tapering and narrower distally 3
2. Body narrow, threadlike (< 0.2 mm wide); first 2 segments not noticeably constricted; dorsal tentacular cirri longer than ventral tentacular cirri .. .. *E. filiformis*
— Body not thin and threadlike (> 0.5 mm wide); segments 1 and 2 strongly constricted; tentacular cirri equal in length ..... *E. robertianae*
3. Prostomium as long or longer than maximum width 4
— Prostomium wider than long 10
4. Dorsal pair of tentacular cirri longer than ventral pair ..... *E. tulua*
— Dorsal and ventral tentacular cirri equal in length 5
— Dorsal pair of tentacular cirri shorter than ventral pair 9
5. Antennae narrow, threadlike ..... *E. japanensis*
— Antennae stout basally, tapering distally 6
6. Proboscis terminating in ring of globular papillae 7
— Proboscis without terminal ring of papillae ..... *E. spetsbergensis*
7. Ventral cirri present from third segment; dorsal cirri circular-ovoid throughout ..... *E. dilatae*
— Ventral cirri present from second segment; dorsal cirri of anterior 10 seg-

ments quadrangular with rounded corners 8
8. Prostomium a truncate triangle; body not conspicuously pigmented ... . *E. californica*
– Prostomium distally very narrow, lateral margins concave; dorsum with heavily pigmented dark brown transverse bands and spots . *E. spilotus*
9. Nuchal papilla absent; anal cirri club-shaped, with distal knob .... *E. columbiensis*
– Nuchal papilla present; anal cirri spherical ..... *E. delta*
10. Dorsal pair of tentacular cirri longer than ventral pair 11
– Both pairs of tentacular cirri similar in length 12
11. Proboscis lacking terminal ring of papilla; setae with single large tooth and several smaller teeth; dorsum with conspicuous transverse brown bars . ..... *E. palari*
– Proboscis with terminal ring of papillae; setae with 2 large teeth equal in size and several smaller teeth; dorsum not conspicuously pigmented ... . *E. trilineata*
12. Proboscis with terminal ring of papillae 13
– Proboscis without terminal ring of papillae 14
13. Dorsal cirri quadrangular anteriorly, ovoid posteriorly; anal cirri digitiform, 2-3 times as long as wide ..... *E. longa*
– Dorsal cirri roughly circular; anal cirri spherical globes .... *E. sculpta*
14. Ventral cirri with pointed tips; ventral pair of antennae longer than dorsal pair; setae with 2 large teeth equal in size ..... *E. suecica*
– Ventral cirri with rounded tips; antennae equal in size; setae with 2 large unequal teeth ..... *E. flava*

Eteone balboensis Hartman

Figures 1a, 14a

Eteone balboensis Hartman, 1936a: 131, figs 49–51, southern California.

Material examined. USA, California, Newport Bay, 12 Oct 1935, O. Hartman, "S 151", USNM 20337, labelled "type" (in Hartman's hand-writing) and "holotype" on a separate label, SEM stub NMV F53920 median RHS parapodium.

Description. The holotype is a headless posterior fragment of 177 segments, 35 mm long, 1.0 (1.7) mm maximum width. Colour in alcohol light brown throughout, no markings or patterns. Dorsal cirri longer than wide, ovoid with rounded tips initially, similar in size but lanceolate with acuminate tips posteriorly. Neuropodia and ventral cirri ovoid-lanceolate, similar in size and shorter than dorsal cirri throughout (fig. 1a). Anal cirrus (one of the pair is lost) digitiform with rounded tip, 3 times as long as wide. Setae with 2 large rounded teeth equal in size and numerous smaller teeth (fig. 14a).

Remarks. Hartman's (1936a) original description includes the following additional information: prostomium about three-quarters as long as wide, without eyes but with nuchal papilla; dorsal cirri symmetrical, longer than wide, rectangular in median region, trapezoidal posteriorly; ventral cirri smaller than neuropodia except on anterior 10–15 segments.

The structure of the proboscis and the form of the anal cirri remain unknown; this information is required before the identity and generic placement of this species can be confirmed.

Distribution. California, USA.

Eteone californica Hartman

Figures 1b–e, 14b

Eteone californica Hartman, 1936a: 131, figs 43–46 (Southern California). – Hartman, 1948: 20, 21, figs 4a–d (Alaska). – Kravitz and Jones, 1979: 9 (Northern Oregon and Southern Washington).

Material examined. USA, California, Berkeley Beach, San Francisco Bay, Nov 1932, coll. and don. O. Hartman, USNM 20339, 2 syntypes, 2 SEM stubs NMV F53921, F53922 segments 11 and 16 RHS parapodia from entire syntype.

Description. Entire syntype 85 segments, 15 mm long, 0.4 (0.7) mm wide; anterior fragment 28 segments, 3.5 mm long, 0.3 (0.6) mm wide. Prostomium slightly longer than wide, tapering anteriorly, anterior margin half width of posterior margin (fig. 1b). Anterior region of prostomium distinctly globular, divided from posterior two-thirds of

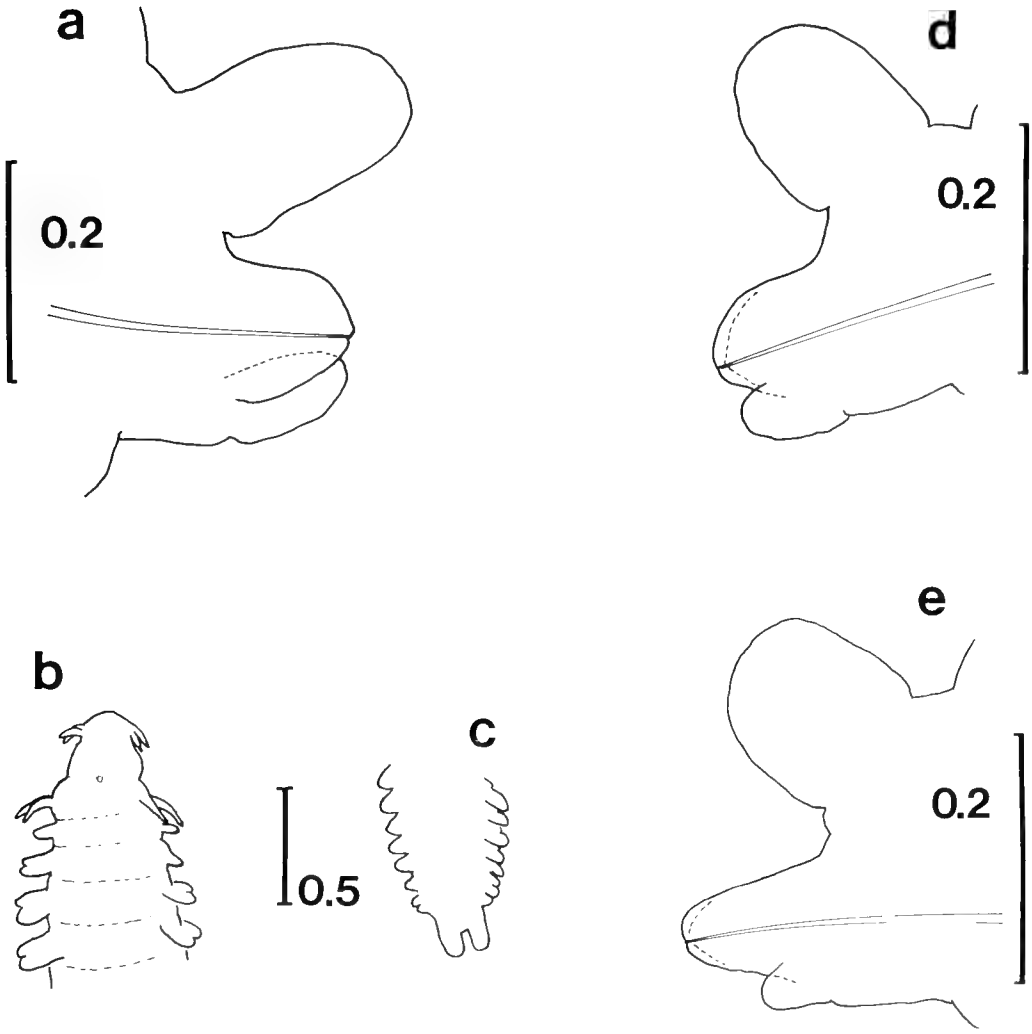

Figure 1. a, *Eteone balboensis*, anterior view median parapodium, USNM 20337 holotype. b-e, *Eteone californica* USNM 20339 larger of 2 syntypes: b, dorsal view prostomium; c, anal cirri; d, setiger 10 parapodium anterior view; e, setiger 50 parapodium anterior view. Scale bars in mm.

prostomium by a constriction. Antennae laterally inserted on globular tip region of prostomium, as long as anterior width of prostomium, with blunt tips. Prostomium with median dorsal groove from posterior margin almost to the tip. One pair of faint red sub-dermal eyes close to posterior margin of prostomium and nuchal papilla located at posterior margin of prostomium. Proboscis, examined through ventral dissection, smooth basally, distally with dorsal ridge and 6–8 diagonal lines on each side giving distal region a rugose appearance. Proboscis terminating in ring of small globular papillae. Tentacular cirri of similar length to antennae but tapering from stout base to fine tip, posteriorly inserted on segment 1. Segment 2 with setae, neuropodial lobes and ventral cirri of similar size and flattened digitiform shape. Dorsal cirri present from segment 3, quadrangular and equal in length to neuropodium. Dorsal cirri and neuropodia of similar length and proportions throughout except on posterior-most segments where dorsal cirri become relatively broader and neuropodia acuminate. Ventral cirri similar in size to neuropodia on anterior 10 segments, reduced posteriorly, significantly smaller by segment 20 and by segment 30 reduced to small digitiform process attached to ventral neuropodial margins (figs 1d, e). Anal cirri laterally inserted, digitiform and 3 times as long

as wide (fig. 1c). Setae with pair of large teeth and 3 tiers each of about 4 or 5 smaller teeth (fig. 14b).

Distribution. West coast of North America from southern California to Alaska.

Eteone columbiensis Kravitz and Jones

Figures 2a–d, plate 1a

Eteone columbiensis Kravitz and Jones, 1979: 10–12, figs 3d–g. Columbia River, west coast USA.

Material examined. USA, northern Oregon/southern Washington, off Columbia River mouth, 46°14.98'N, 124°04.83'W, Stn 217D grab 3, 14 m, 26 Jun 1975, A. Carey, 2 paratypes, USNM 57963; SEM stub NMV F53923 segment 11 parapodium from larger of 2 paratypes.

Description. Two entire specimens, 126 segments, 17 mm long, 0.4 (0.5) mm wide and 196 segments, 26 mm long, 0.5 (0.6) mm wide. Prostomium almost twice as long as maximum width at posterior margin, narrowing sharply in mid-section so that anterior half through to anterior margin is third width at posterior margin. Antennae equal in length to width of prostomium at posterior margin. Prostomium with median dorsal groove and pair of dark red eyes at posterior margin; nuchal papillae not visible (fig. 2a). Proboscis fully retracted (not previously dissected in either paratype) narrow and difficult to see, apparently smooth basally and covered with minute papillae distally, with terminal ring of 15 or more large papillae. Ventral tentacular cirri third as long as width of first segment, dorsal pair slightly shorter. Second segment with setae, ovoid neuropodia and smaller digitiform ventral cirri. Dorsal cirri present from segment 3, initially half length of neuropodia and trapezoid in shape, narrower at base than on distal margin, distal margin slightly rounded. Dorsal cirri becoming proportionately larger posteriorly, as long as neuropodia by segment 40 and more rounded in outline. Ventral cirri asymmetrical, ovoid and smaller than neuropodia throughout. Cirri and neuropodia of similar proportions posterior to segment 40 but reducing in overall size on posterior-most segments (figs 2c, d). Anal cirri stout with distinct distal knob, twice as long as wide and as long as last 3 or 4 segments (fig. 2b). Setae with 1 large tooth with slightly smaller tooth on each side and many successively smaller teeth in 5 or 6 tiers (pl. 1a).

Remarks. Eteone columbiensis has distinctive setae which are unlike those of any other species examined in this study.

Distribution. Known only from the original material collected from off the mouth of the Columbia River, west coast of the USA.

Eteone delta Wu and Chen

Eteone delta Wu and Chen, 1963: 18, 19 (in Chinese), 30 (in English), fig. 1, pl. 1 figs a–e, pl. 2 fig. a. Yangtse River Delta, Shanghai, China. – Uschakov, 1974: 167, pl. 16 figs 1–6 (record repeated).

Remarks. A summary of the critical taxonomic characters is as follows (from Wu and Chen, 1963): prostomium as long as wide, with biarticulate antennae. One pair of black eyes. Nuchal papilla at posterior margin of prostomium. Dorsal pair of tentacular cirri slightly shorter than ventral pair. Everted proboscis slightly wrinkled but otherwise smooth, distal end with circle of 12 subglobular cirri surrounding the orifice. Setae present from second segment. All parapodial lobes subquadrangular with rounded tips. Dorsal and ventral cirri shorter than neuropodia in middle and anterior regions but both cirri exceed length of neuropodia in posterior-most segments. Anal cirri short, globular. Setae with 1 large tooth and series of smaller teeth at end of shaft.

Distribution. Known only from the Yangtse River Delta, Shanghai, China.

Eteone dilatae Hartman

Figures 2e–h, plate 1b

Eteone dilatae Hartman, 1936a: 130, 131, figs 40–42. Central California.

Material examined. USA, California, Dillon Beach, Jul 1933, coll. Williams, USNM 20338, syntype; SEM stubs NMV F53924, F53925 segments 11 and 21 LHS parapodia.

Description. An anterior fragment with proboscis fully everted, 84 segments, 26 mm long, 0.9 (1.1) mm wide; and a posterior fragment, tightly coiled, of 253 segments (the posterior fragment exceeds the diameter of the anterior and it is possible that 2 individual worms are represented). Colour pale yellow, no markings. Prostomium longer than wide, triangular with anterior point slightly bulbous and truncate. Antennae as long as anterior width of prostomium. One pair of faint red sub-dermal eyes present close to posterior margin of prostomium and small nuchal papilla on posterior margin. A median dorsal groove runs from posterior margin almost to tip of prostomium (fig. 2e). Everted proboscis as long as anterior 12 segments, without papillae and smooth over proximal four-fifths, a constriction dividing the distal fifth which is slightly rugose, with terminal ring of 15 or more irregular globular papillae (fig. 2e). Ten-

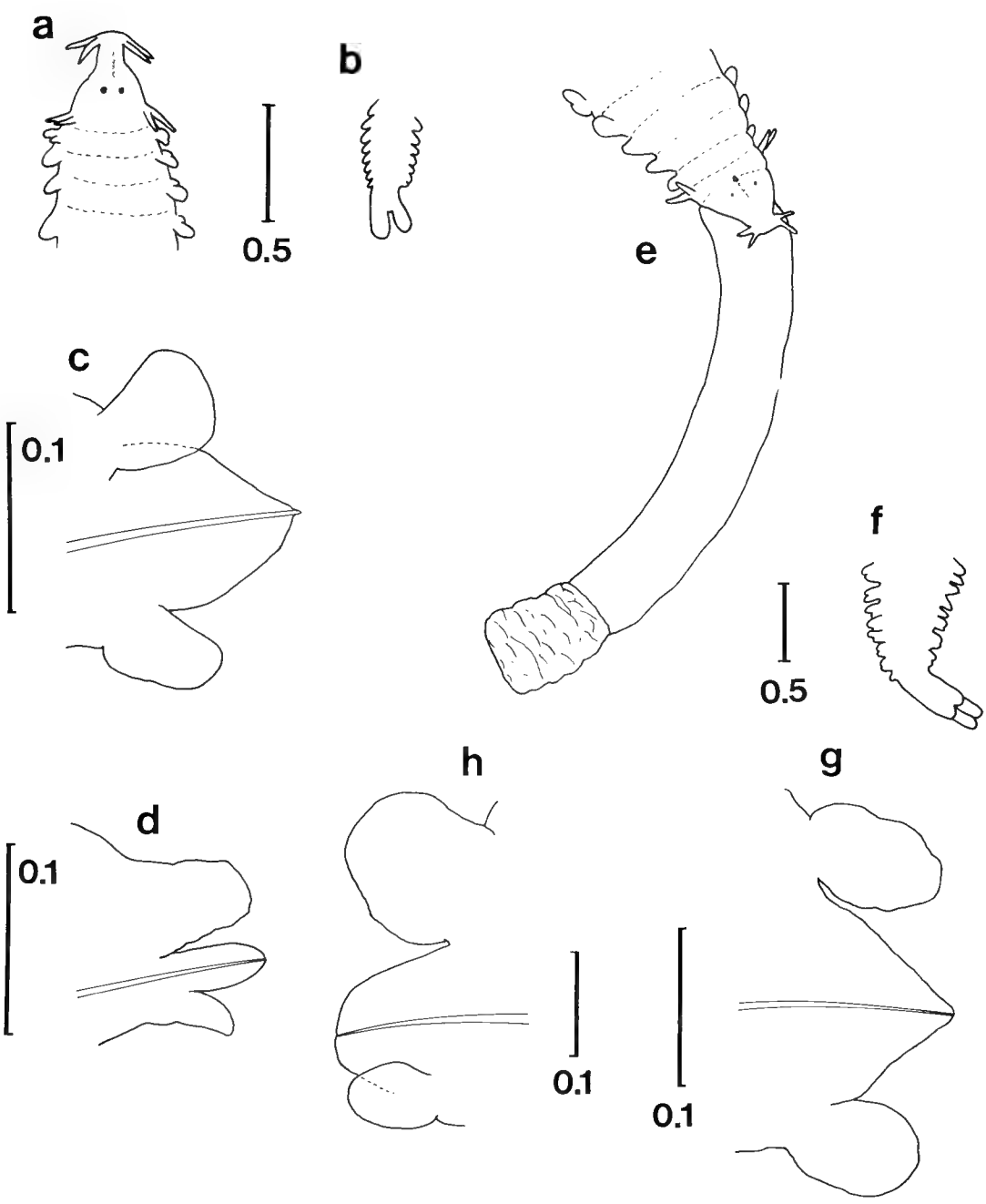

Figure 2. a–d, *Eteone columbiensis* USNM 57963 larger of 2 paratypes: a, dorsal view prostomium; b, anal cirri; c, setiger 10 parapodium posterior view; d, setiger 40 parapodium posterior view. e–h, *Eteone dilatae* USNM 20338 syntype: e, prostomium and everted proboscis dorsal view; f, anal cirri and ventral lappets ventral view; g, setiger 10 parapodium anterior view; h, setiger 50 parapodium anterior view. Scale bars in mm.

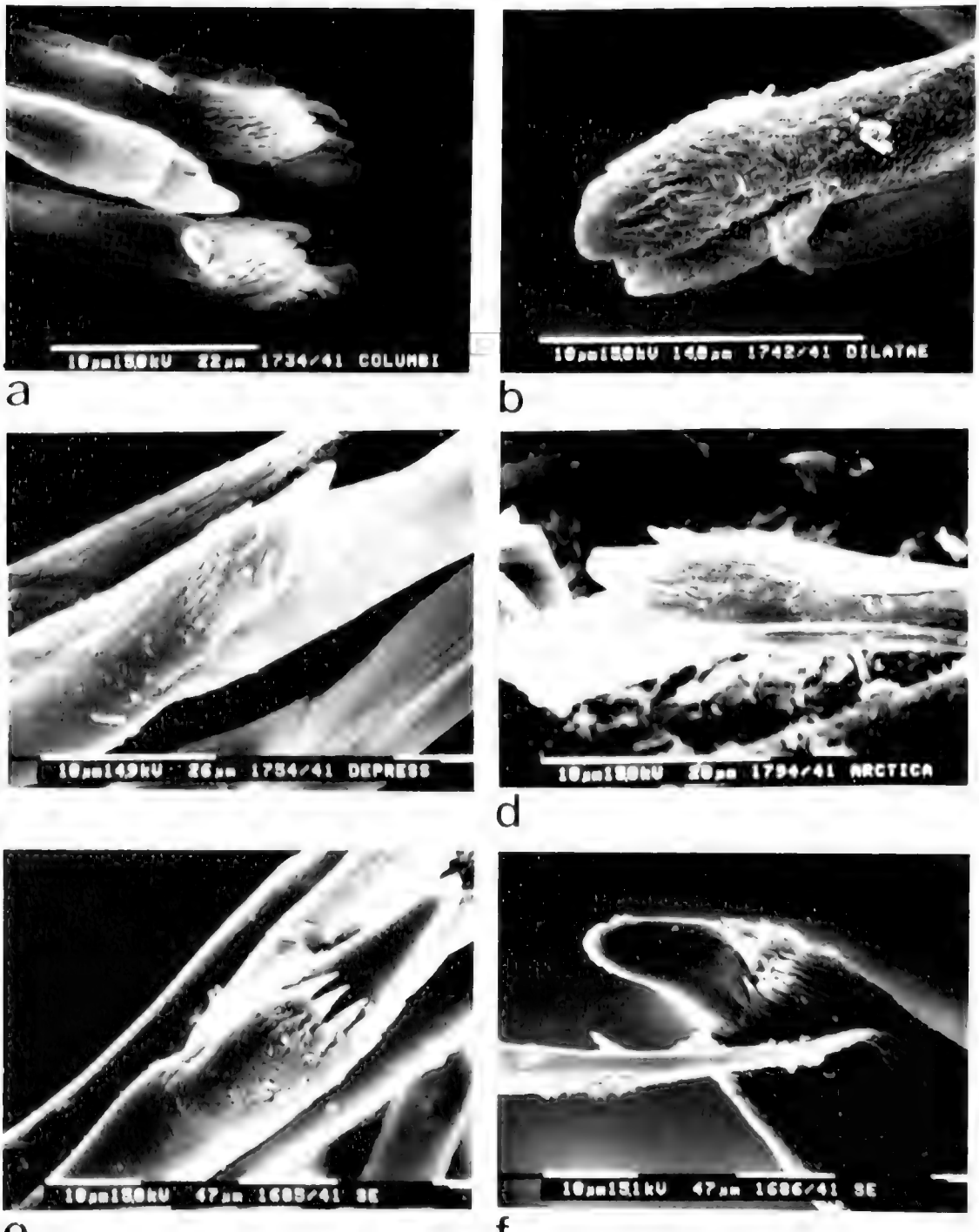

Plate I. Scanning electron micrographs of setae of species of *Ecteone*. a, *E. columbiensis* USNM 57963 largest of 7 paratypes (from setiger 10); b, *E. dilatae* USNM 20338 paratype (from setiger 20); c, *E. flava* (*E. depressa* SMNH 7413 syntype from setiger 10); d, *E. longa* (*E. arctica* SMNH 2408 syntype, from setiger 10); e, f, *E. palari* QM GH38?? holotype (from setiger 28). Scale bars in µm.

tacular cirri equal in length, slightly shorter than antennae. Second segment with setae and very small neuropodia, ventral cirri absent. Rudimentary dorsal and ventral cirri present on segments 3 and 4, becoming fully developed posteriorly. Dorsal cirri small and ovoid anteriorly, becoming circular from about segment 35. Neuropodia ovate, anteriorly twice as long as dorsal cirri but reducing posteriorly so that dorsal cirri and neuropodia of equal length by about segment 40. Ventral cirri ovoid to circular, attached to ventral neuropodial margin, anteriorly about as long as dorsal cirri and remaining small throughout (figs 2g, h). Anal cirri about 2 or 3 times as long as wide and as long as posterior 2 or 3 segments; pygidium also with pair of knob-like ventral lappets (fig. 2f). Setae with pair of large rounded teeth, equal or only slightly dissimilar in size, and numerous small teeth in 3 or 4 tiers (pl. 1b).

Remarks. There is some confusion as to the status of the USNM type material. The original label, in Hartman's hand-writing, states "type", and the original descriptions state that holotypes of all species described by Hartman (1936a) were deposited with the USNM, yet the type locality, "outer side of Bodega sand spit, Sonoma County" does not agree with the present material from Dillon Beach, Marin County (this locality was listed by Hartman but not as type locality). The label shows that Hartman intended that this material should be designated as types and they are here treated as syntypes.

The description above agrees with that of Hartman (1936a) except that the proboscidial papillae recorded by Hartman were absent from the USNM syntype. The "soft papillae on the distal half" noted by Hartman may correspond to the rugose distal portion of the proboscis as described here.

Distribution. California, west coast USA.

Eteone filiformis Hartman-Schröder

Eteone filiformis Hartman-Schroder, 1980: 45, 46, figs 19–22.

Material examined. Australia, WA, Port Samson, mangrove estuary south of the town, sand with *schill* and much plant detritus, 1 Oct 1975, coll. G. Hartmann Schroder, HZM P-16206, 2 paratypes.

Description. Two entire specimens: 124 segments, approx. 8 mm long; 109 segments, approx. 12 mm long; both approx. 0.15 mm wide (0.2 mm). Prostomium and first segment fused, no external sign of any division or septum; together almost twice as long as wide, maximum width at posterior margin about twice width at anterior margin. Antennae threadlike, as long as width of prostomium at anterior margin. One pair of brown eyes on posterior quarter of prostomium. Tentacular cirri threadlike, located slightly behind eyes. Dorsal pair of tentacular cirri about half as long as posterior width of prostomium, ventral pair slightly shorter. First distinct segment with setae, digitiform neuropodia and ventral cirri. Dorsal cirri ovoid, present from segment 2. Neuropodium with rounded margin and slightly longer than dorsal cirri throughout. Ventral cirri ovoid and as long as neuropodia. Parapodial lobes similar throughout. Anal cirri almost spherical lobes. Setae appear to have 2 equal or only slightly dissimilar large teeth and 1 or 2 tiers of smaller teeth.

Remarks. Eteone filiformis is known only from the holotype and two paratypes; all are minute threadlike specimens which are unlike any other species of *Eteone*. The holotype figured by Hartmann Schröder (1980) has a proboscis which is smooth but apparently only partly everted. The type material is too small and scarce to attempt to dissect the proboscis or mount material for SEM examination of setae.

Distribution. Known only from the original material, Port Samson, north western Western Australia.

Eteone flava (Fabricius)

Figures 3a–e, plate 1c

Nereis flava Fabricius, 1780. West Greenland.

Eteone flava. Uschakov, 1974: 165, 166, pl. 15 figs 4–7. Synonymy.

Eteone depressa Malmgren, 1865: 103, pl. 15 figs 36a–d Spitsbergen and Greenland. Malmgren, 1867: 149 (record repeated)

Eteone lentigera Malmgren, 1867: 149, 150, pl. 3 figs 13a–d. Spitsbergen.

Material examined. Svalbard (Spitsbergen), Bellsund, 30–40 fm [55–73 m], O. Torell, SMNH 2413, 5 syntypes of *E. depressa*, SMNH SEM stub segment 11 LHS parapodium; Bellsund, 30–40 fm [55–73 m], steng lerb, 1858, O. Torell, SMNH 2414, 3 syntypes of *E. depressa*; Treurenberg Bay, Spetsbergen Expedition 1861, SMNH 359, 2 syntypes of *E. lentigera*

Description. (based on *E. depressa* syntypes) The syntype series includes at least 8 specimens, comprising 3 entire worms (size range 106 segments, 39 mm long, 1.5 (2.1) mm wide to 136 segments (regenerating posteriorly), 88 mm long, 2.3 (3.9) mm wide), 5 anterior fragments (largest 67 segments, 40 mm long (excluding everted proboscis 9 mm), 2.7 (4.4) mm wide), 7 median fragments and 3 posterior fragments. Colour in alcohol pale

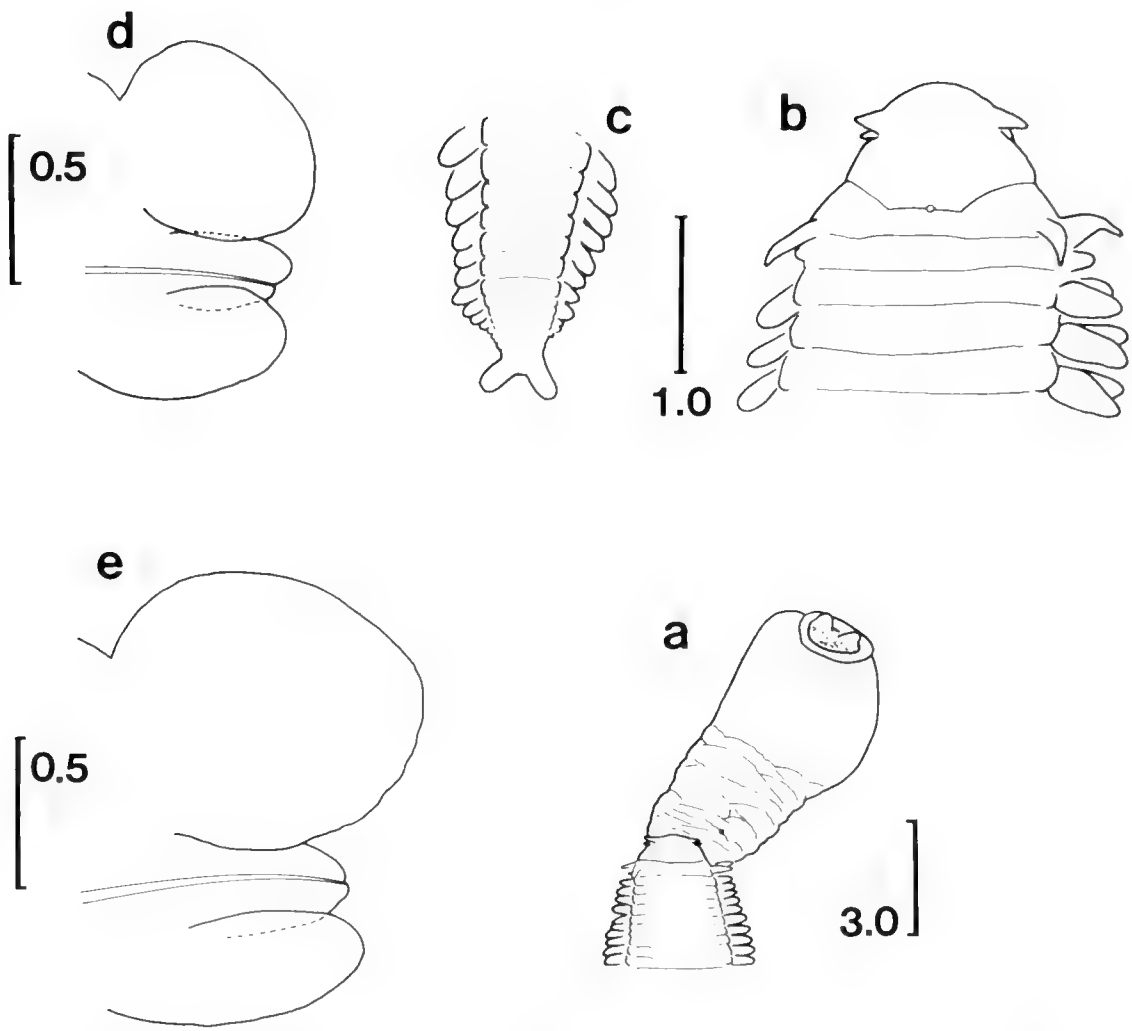

Figure 3. *Eteone flava* (*Eteone depressa* syntypes, SMNH 2413): a, everted proboscis dorsal view; b, prostomium dorsal view; c, anal cirri; d, setiger 10 parapodium posterior view; e, setiger 50 parapodium posterior view. Scale bars in mm.

brown, no markings. Prostomium two-thirds as long as wide; anterior margin rounded, two-thirds as wide as posterior margin. Eyes absent, median nuchal papilla located on posterior margin of prostomium (difficult to see in some syntypes). Antennae stout basally, with pointed tips, quarter as long as anterior width of prostomium (fig. 3b). Proboscis everted in 1 syntype, as long as anterior 26 segments, rugose and wrinkled on basal half, smooth distally; remaining syntypes with proboscis retracted, when dissected striated but smooth proximally, distally coarsely rugose with large tuberculae irregularly arranged. Orifice of proboscis directed obliquely dorsally and anteriorly, surrounded by smooth fleshy ring and with pair of large papillae (1 on each side, in ventro-lateral positions) projecting from the opening (fig. 3a). Tentacular cirri located at posterior margin of first segment, equal in length and quarter as long as width of first segment. Second segment with setae, lanceolate neuropodia and ventral cirri, ventral cirri slightly longer than neuropodia throughout. Dorsal cirri present from segment 3, asymmetrical ovoid to circular, equal in diameter to length of neuropodia on anterior segments, becoming larger posteriorly so that from about segment 40 diameter of dorsal cirri is about 1.25 times length of neuropodia (figs 3d, e). Anal cirri laterally inserted, digiti-

form, 2–4 times as long as wide, slightly club-shaped in some syntypes (fig 3c). Setae with 2 large acutely pointed teeth slightly dissimilar in size and only 12–15 smaller teeth in 3 or 4 tiers (pl. 1c).

Remarks. The type material of *Eteone flava* is lost (K. Fauchald and F. Pleijel, pers. comm.), however there is general agreement among other authors that *E. depressa* is a junior synonym (Bergström, 1914; Hartmann-Schröder, 1971; Uschakov, 1974; Pleijel, in prep.). The above description agrees closely with previous descriptions of Bergström (1914) and Uschakov (1974) except that there is some variability in the proboscis. Bergström (1914) stated that the proboscis was smooth whereas Malmgren (1865) and Uschakov (1974) show that the proboscis is partly or wholly tuberculate. There is also some variability among the material examined here; tuberculae are more pronounced in dissected specimens in which the proboscis is retracted, and one of the syntypes of *E. lentigera* (which otherwise agree with the description above) has a fully everted proboscis which is smooth in the extreme basal region and distally but is wrinkled and tuberculate in a broad median section. It seems that the appearance of the proboscis depends in part on the degree of contraction of the specimen and the variability observed is probably not taxonomically significant.

Eteone sarsii Ørsted, 1843 (the type material of which is lost, K. Fauchald and F. Pleijel, pers. comm.), described from Sweden, was given as a junior synonym of *E. flava* by Hartman, 1959; on what basis or authority is not clear.

Eteone fucata M. Sars

Figures 4a, 14c

Eteone fucata Sars, 1872: 407. Norway.

Material examined. Norway, Christianafjord, Droback, ZMO unregistered, syntype fragments, SEM stub NMV F53926 median parapodium.

Description. Sars' original material consists of 7 median fragments for a total of 228 segments, maximum width 1.5 (3.0) mm; both head/anterior segments and anal cirri are missing. Colour in alcohol pale yellow, no markings. Dorsal cirri asymmetrical ovoid, neuropodia triangular and ventral cirri ovoid-lanceolate, all of similar length (fig. 4a). Proportions of lobes similar over all segments but parapodia of presumed posterior segments smaller overall. Setae with pair of large teeth slightly dissimilar in size, otherwise smooth and without tiers of small teeth at the articulation (fig. 14c).

Distribution. Christianafjord, Norway.

Remarks. Hartman (1959) and Hartmann-Schröder (1971) have suggested that *Eteone fucata* is possibly synonymous with *E. flava* (Fabricius, 1780), however the distinctly asymmetrical dorsal cirri differ from those figured herein for *E. flava*. The setae, which lack rows of small teeth, are also distinctive and appear to be unique for the genus. The original description of *E. fucata* by Sars (1872) states that the anal cirri are conical-acuminate and equal to four to five segments in length, further distinguishing *E. fucata* from *E. flava* and related species; if verified, this would require that *E. fucata* be transferred to the genus *Hypereteone* as defined in this paper. The proboscis is unknown but should be found to carry longitudinal ridges of tuberculate papillae if this is indeed a species of *Hypereteone*.

Eteone japanensis McIntosh

Figures 4b–d, 14d

Eteone japanensis McIntosh, 1901: 222. Japan Sea.

Material examined. Japan Sea, BMNH ZK 1921.5.1.1059, holotype, BMNH SEM stub segment 16 parapodium.

Description. Holotype an entire specimen, 133 segments, 26 mm long, 0.5(0.8) mm wide at segment 10. Colour in alcohol pale yellow-cream, no pigmentation. Prostomium 1.25 times as long as wide, anterior margin rounded, three-quarters as wide as posterior margin. Antennae threadlike, as long as anterior width of prostomium, and pair of large red eyes close to posterior margin of prostomium. Prostomium strongly dorso-ventrally flattened; nuchal papilla not visible (fig. 4c). First segment appears partly fused to prostomium, only faint division visible. Proboscis fully retracted, not previously dissected, extends back to segment 10, details unclear but without obvious tuberculae or papillae. Tentacular cirri equal in length to width of first segment, stout basally and tapering to very fine tip. Second segment with setae, ovoid neuropodia and ventral cirri smaller than those of subsequent segments. Dorsal cirri present from segment 3, ovoid lanceolate and similar in length to neuropodia anteriorly, slightly longer than neuropodia posterior to about segments 60-70. Neuropodia and ventral cirri ovoid lobes, ventral cirri slightly exceeding length of neuropodia throughout (fig. 4b). Anal cirri ovoid-digitiform with rounded tip, slightly wider at base and about twice as long as maximum width (fig. 4d). Setae few in number (6–8 per parapodium), with 2 large teeth slightly dissimi-

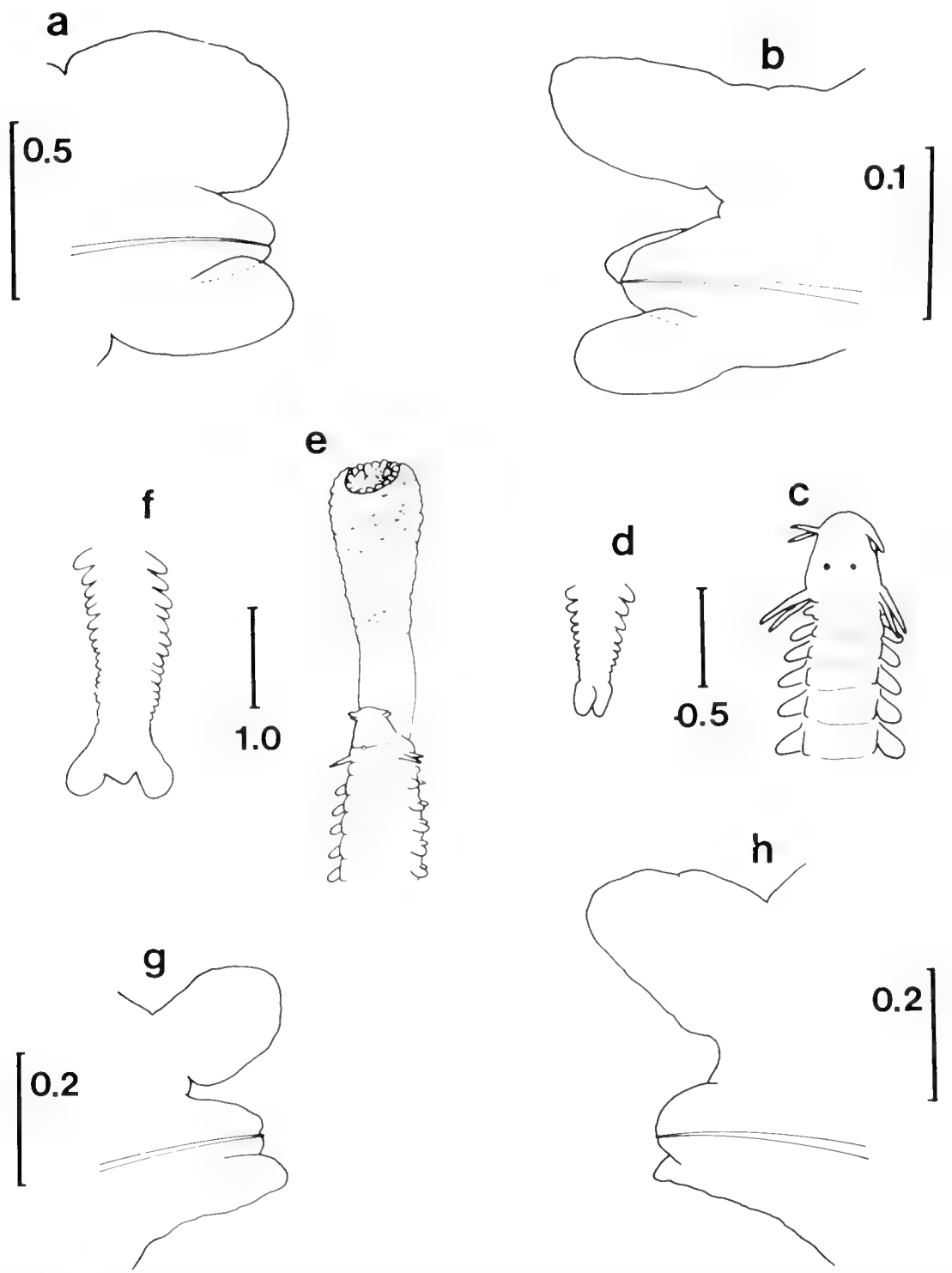

Figure 4. a, *Eteone fucata* ZMO syntype median parapodium anterior view. b–d, *Eteone japanensis* BMNH ZK1921.5.1.1059 holotype: b, setiger 15 parapodium anterior view; c, prostomium dorsal view; d, anal cirri. e–h, *Eteone longa* (*Eteone arctica* SMNH 2408 syntypes): e, prostomium and everted proboscis dorsal view; f, anal cirri; g, setiger 15 parapodium posterior view; h, setiger 100 parapodium anterior view. Scale bars in mm.

lar in size and apparently with only 1 tier of a few small teeth (fig. 14d).

Distribution. Known only from the Japan Sea.

Eteone limicola Verrill

Eteone limicola Verrill, 1873: 588. New Jersey.—Hartman, 1942: 42 (re-examination of type).

Material examined. USA, New Jersey, Beesleys Point, Great Egg Harbour, in sand, low water, Apr 1871, A.E. Verrill and S.I. Smith, YPM 36, syntype, SEM stub NMV F53927 about segment 26 RHS parapodium.

Description. The syntype (so labelled, but apparently the only type specimen in existence; Hartman, 1942), an anterior fragment of about 160 segments, 52 mm long, is in very poor condition having dried out and been returned to 70% ethanol some time prior to Hartman's (1942) examination of the specimen. The soft parts of the specimen are too shrunken and distorted to be described. Setae with 2 large teeth of similar size and at least 10 small teeth in 2 or 3 tiers (described from SEM photograph).

Remarks. Verrill's (1873) description includes the following information: colour in life light green throughout; prostomium as long as wide, with a slight constriction in advance of eyes, narrowing rapidly anteriorly; antennae about half as long as prostomium; tentacular cirri as long as prostomium; dorsal cirri and parapodial lobes small anteriorly, becoming much larger on posterior segments. Since Verrill makes no mention of the structure of the proboscis or the anal cirri, the placement of this species in *Eteone* is uncertain.

Distribution. Recorded only from Great Egg Harbour, New Jersey, USA.

Eteone longa (Fabricius)

Figures 4e–h, plate 1d

Nereis longa Fabricius, 1780: 300. West Greenland.

Eteone longa.—Uschakov, 1974: 166, 167, pl. 15 figs 8–10. Synonymy.—Kravitz and Jones, 1979: 9. Southward range extension to northern Oregon, USA.

Eteone arctica Malmgren, 1867: 148, 149, pl. 3 figs 12a–d. Spitsbergen.

Eteone islandica Malmgren, 1867: 148, pl. 4 figs a–d. Iceland.

Eteone leuckarti Malmgren, 1867: 149, pl. 3 figs 15a–d. Iceland.

Eteone lilljeborgi Malmgren, 1867: 148, pl. 4 figs 22a–d. Sweden.

Eteone robusta Verrill, 1873: 588. Rhode Island and Massachusetts (fide Pettibone, 1963: 73).

Material examined. Svalbard (Spitsbergen). Safehavn, 10–30 fm [18–55 m], A.J. Malmgren, SMNH 2408, 9 syntypes of *E. arctica* and SMNH SEM stub segment 11 RHS parapodium; Treuerenbb., 20 fm [37 m], Spetzbergen Expedition 1861, SMNH 2409, 11 syntypes of *E. arctica*.

Iceland. Raufarhavn, 30 fm [55 m], SMNH 2406, 3 syntype fragments of *E. islandica*; Berufjord, 25 fm [46 m], O. Torell, SMNH 2407, 1 syntype of *E. islandica*; Thistlefjord, 10-16 fm [18–29 m], O. Torell, SMNH 2410, 3 syntypes of *E. leuckarti*; Jutefjord? [label unclear], 10-16 fm [18–29 m], O. Torell, SMNH 2411, 1 syntype of *E. leuckarti*. Bohuslan ("Bahusia" in Malmgren, 1867): S. Loven, SMNH 2405, 2 syntypes of *E. lilljeborgi*.

USA, USNM 26964, 3 type slides labelled anterior, middle, and last feet, *E. cinerea*.

Description. (based on syntypes of *E. arctica*) Size range 87 segments, 18 mm long, 0.7 (1.1) mm wide to 134 segments, 75 mm long, 1.0 (1.5) mm wide (entire specimens). Colour in alcohol pale yellow. Prostomium three-quarters as long as wide, a truncate triangle with rounded anterior margin half as wide as posterior margin. Antennae third to half as long as width of anterior margin of prostomium. No eyes visible. A prominent nuchal papilla on posterior margin of prostomium (fig. 4e). Fully everted proboscis (on 5 syntypes) up to 3 mm long, equal to anterior 15 segments, consists of smooth tube over the basal half, coarsely tuberculate over the distal half. Proboscis terminating in ring of 15 globular papillae surrounding the orifice with additional pair of papillae (1 on each side) projecting from orifice (fig. 4e). Tentacular cirri equal in length and about third as long as width of first segment. Second segment with setae, rounded neuropodia and digitiform ventral cirri extending beyond the tip of neuropodia. Neuropodia shorter than ventral cirri anteriorly, ventral cirri reducing in size so that neuropodia and ventral cirri of equal length by about segment 30, ventral cirri present as small lobe attached to ventral margin of neuropodia on subsequent segments. Dorsal cirri present from segment 2, quadrangular with rounded tip and as long as ventral cirri over anterior 10–20 segments, dorsal cirri exceeding ventral cirri in length from about segment 30 and posteriorly, reaching maximum length and becoming ovoid lanceolate in shape over segments 40–50, tending to triangular and reducing in size over posterior segments (figs 4g, h). Anal cirri globular to digitiform lobes up to twice as long as wide (fig. 4f). Setae with 2 large teeth equal or only slightly dissimilar in size and many quite small teeth in about 4 tiers (pl. 1d).

Remarks. Two specimens among the syntypes of *E. arctica* (SMNH 2409) have large circular dorsal cirri and dissected probosces in poor condition and

may not be conspecific with the remaining syntypes. The syntypes of *E. islandica* and *E. lilljeborgi* agree closely with *E. arctica* in the form of the prostomium, tentacular cirri, proboscis and anal cirri and the synonymies proposed by Bergström (1914) and Hartman (1959) are accepted here. The syntypes of *E. leuckarti* differ only in that the anal cirri are more elongate (up to 5 times as long as wide) than in *E. arctica*; this synonymy is also confirmed.

The holotype of *Eteone robusta* is a gravid female and also agrees closely with the above description of *E. arctica*. Hartman's (1942) redescription of this specimen states that the proboscis is smooth, however the dissection that had been performed on the specimen was incomplete and revealed only part of the digestive tract posterior to the proboscis; further anterior dissection showed that the proboscis proper is coarsely rugose throughout and terminates in a ring of 15 papillae with an additional pair of lateral papillae immediately posterior to the terminal ring of papillae.

Eteone cinerea Webster and Benedict, 1884 was synonymised with *E. longa* by Pettibone (1963); the parapodia of *E. cinerea* examined here (type slides, USNM 26964) are similar to those of *E. longa* however I am not sufficiently confident to make this synonymy based on such limited material. *Eteone villosa* Levinsen, 1882, was listed as a junior synonym of *E. longa* by Hartman (1959) but without citing any authority.

Distribution. Arctic-boreal; widely reported from North Pacific and Atlantic Oceans.

Eteone pacifica Hartman

Eteone pacifica Hartman, 1936b: 31. Washington. New name for *Eteone maculata* Treadwell, 1922: 174 (preoccupied); not Ørsted, 1843. - Hartman, 1936a: figs 47, 48. - Banse, 1972: 191-193, fig 1a-l (redescription).

Remarks. The following information is taken from the redescription of the holotype by Banse (1972). Prostomium about as long as wide, posterior margin only slightly wider than anterior margin. Antennae short, small nuchal papilla present. Tentacular cirri short and equal in length (on one side; unequal but apparently regenerating on the other side). Second segment with neuropodia, setae and ventral cirri. Dorsal cirri from segment 3, ear-shaped and strongly asymmetrical except on anterior-most parapodia, carried on distinct cirrophore on most median and posterior segments. Ventral cirri and neuropodia ovoid and roughly as long as dorsal cirri throughout. Setae with two unequal large teeth and several smaller teeth. Anal cirri not described. The proboscis had been removed from the holotype when examined by Banse and had not been described by Treadwell (1922) or Hartman (1936a, 1936b), hence the placement of this species in *Eteone* is uncertain.

Distribution. Known from the type locality, Friday Harbour, Washington State; also recorded by Hartman (1936b) from Moss Beach, San Mateo County, California, west coast USA.

Eteone palari sp. nov.

Figures 5a-e, plates 1e, f

Material examined. Holotype: Australia, Queensland, Bramble Bay, Moreton Bay, Stns 21 and 32, approximately 5 m, mud, van Veen Grab, Sep 1972, coll. S. Cook, QM GH3577 (for further locality details see Stephenson et al., 1976), 2 SEM stubs NMV F53928, F53929 segment 21 LHS and segment 26 RHS parapodia.

Paratypes: Data as for holotype, QM GH4107, 1 paratype; Bramble Bay, Moreton Bay, Stn 3B, Jun 1975, coll. S. Cook, QM GH3633, 1 paratype; Middle Banks, northern Moreton Bay, Stn 4B, van Veen Grab, Jun 1975, coll. S. Cook, QM GH3639, 1 paratype; Middle Banks, northern Moreton Bay, Stn 6E, van Veen Grab, Jun 1975, coll. S. Cook, QM GH3654, 1 paratype.

Description. Holotype an anterior fragment with proboscis everted, 159 segments, 88 mm long, 1.6 (3.2) mm wide. Size range of entire paratypes: 106 segments, 12 mm long, 0.6 (0.8) mm wide to 231 segments, 95 mm long, 1.6 (3.3) mm wide. Body pale brown throughout, with single darker brown transverse band across the dorsum of each segment (dorsal bands slightly faded in holotype but very distinct in several paratypes). Prostomium almost semi-circular in shape, about two-thirds as long as wide, anterior margin rounded and projecting beyond antennae, width between antennae about two-thirds width at posterior margin. One pair of small dark eyes on posterior quarter of prostomium. Nuchal papilla absent (figs 5a, b). Dorsal pair of antennae approximately half as long as anterior width of prostomium, ventral pair (partly obscured in dorsal view) slightly shorter. Proboscis fully everted in holotype (fully retracted in all paratypes), as long as anterior 12 segments and divided into 2 distinct regions: proximal half about as wide as anterior body segments, slightly rugose dorsally and smooth but with faint longitudinal striations ventrally. Distal region of proboscis considerably expanded (to almost twice width of proximal region), more coarsely rugose dorsally and with longitudinal striations still visibly ventrally. Buccal opening directed upward, with 2 large conical papillae projecting from ventral region of the orifice.

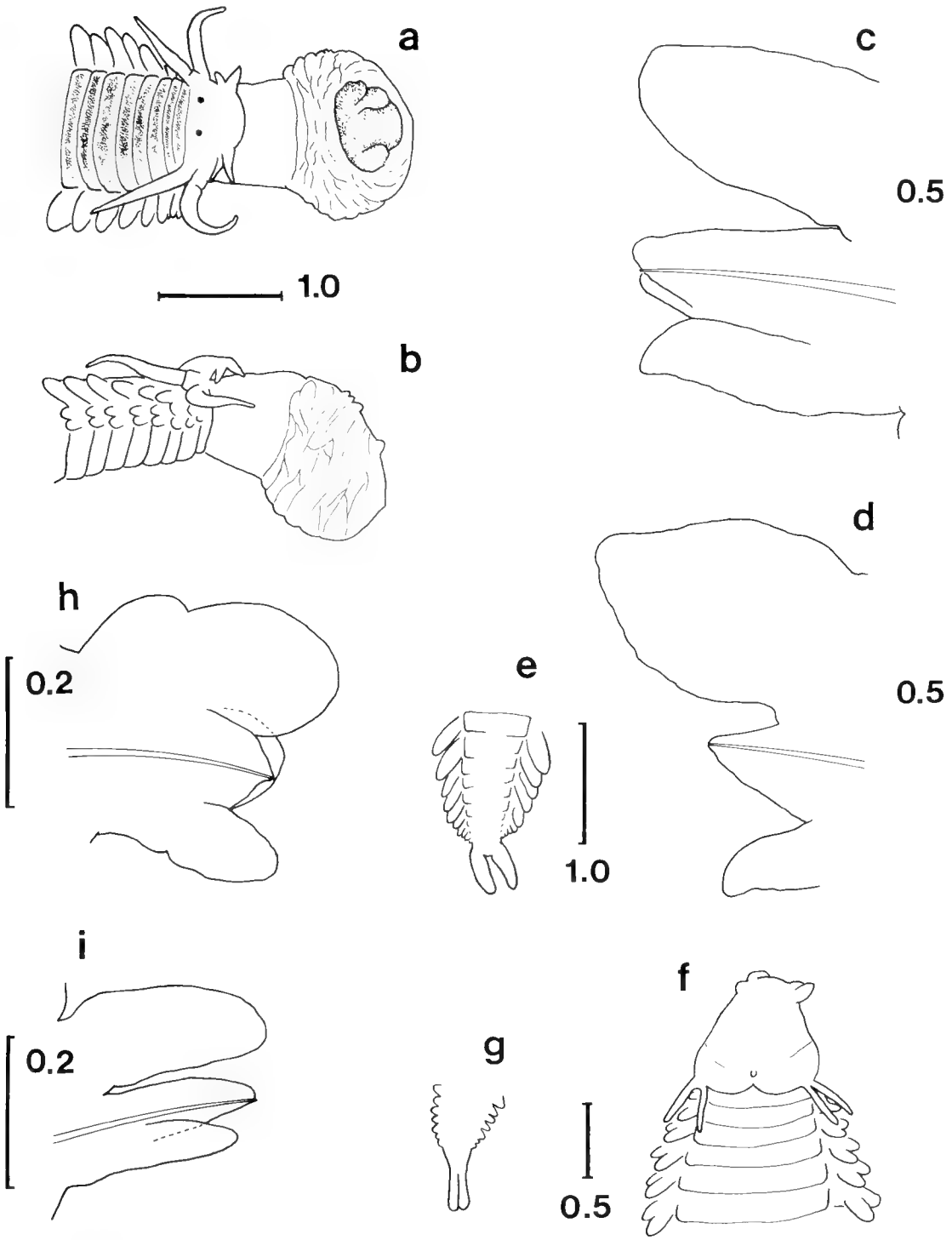

Figure 5. a–d, *Eteone palari* QM GH3577 holotype: a, prostomium and everted proboscis dorsal view; b, prostomium and everted proboscis lateral view; c, setiger 20 parapodium anterior view; d, setiger 50 parapodium anterior view. e, *Eteone palari* QM GH4107 paratype anal cirri. f–i, *Eteone robertianae* BMNH ZK1921.5.1.1044 holotype: f, prostomium dorsal view; g, anal cirri; h, setiger 15 parapodium posterior view; i, setiger 92 parapodium posterior view. Scale bars in mm.

Several smaller inconspicuous papillae line the dorsal rim of orifice (figs 5a, b). Form of proboscis apparently similar in dissected paratypes though structures less clear. Dorsal pair of tentacular cirri about as long as width of first segment, ventral pair about two-thirds as long. Second segment with setae, small lanceolate neuropodia and ventral cirri of similar size and shape. Dorsal cirri present from segment 3, initially lanceolate, becoming elongate-ovoid by segment 15. Neuropodia and ventral cirri lanceolate acuminate and of similar proportions throughout. All parapodial lobes similar and increasing in size over anterior 15–20 segments, dorsal cirri becoming further expanded and relatively longer than the other lobes posterior to segment 20, reaching maximum of twice length of other parapodial lobes by segment 50, thereafter of similar proportions on all posterior segments (figs 5c, d). Anal cirri missing from the holotype; paratypes with digitiform anal cirri, about 4 times as long as wide (fig. 5e). Setae with single large tooth and 2 or 3 tiers of smaller teeth (pl. 1e, f).

Remarks. *Eteone palari* differs from most species of *Eteone* by having the dorsal tentacular cirri longer than the ventral and the maximum width of the prostomium exceeding its length. Only *E. filiformis* and *E. trilineata* share these characteristics but can be distinguished as follows: *E. filiformis* has a narrow threadlike body and prostomium fused with the first segment, readily distinguishing it from *E. palari*. *Eteone trilineata* is similar to *E. palari* but has a ring of large globular papillae surrounding the buccal opening (*E. palari* has only 2 large papillae and several small indistinct papillae at the buccal opening). *Eteone palari* is also distinguished from these and all other species of *Eteone* by the unique setae which have only a single large tooth.

Etymology. The specific name *palari* is derived from an Australian Aboriginal word meaning different and is to be treated as indeclinable.

Distribution. Recorded only from Moreton Bay, Queensland, Australia, shallow muddy sediments.

Eteone robertianae (McIntosh)

Figures 5f–i

Eteonella Robertianae McIntosh, 1874: 197. Scotland.
Eteone arctica var. *robertiana* McIntosh, 1908: 103, 104, pl. 69 figs 8 and 9.

Material examined. Scotland, St Andrews, BMNH ZK 1921.5.1.1044, holotype and BMNH SEM stubs segments 16 and 93 RHS parapodia.

Description. Holotype a single entire specimen in 2 fragments for total of 126 segments, 35 mm long, 1.2(1.7) mm wide at segment 10. Colour in alcohol yellow-white, no pigment patterns. Prostomium almost completely fused with first segment, only faint division visible; together as long as maximum width, width of anterior margin about third maximum width. Antennae stout, shorter than anterior width of prostomium, ventrally directed and not clearly visible from above. No eyes visible. A small distinct nuchal papilla present on mid-dorsal posterior margin of prostomium (fig. 5f). Proboscis (not previously dissected) extends back to segment 12 in retracted position, uniformly rugose with longitudinal folds in retracted position but without thick ridges. Buccal opening with terminal ring of 11 or 12 globular papillae and pair of large lateral papillae. Tentacular cirri threadlike, each about half as long as width of first segment. First and second segments strongly constricted. Second segment with setae, vestigial neuropodia and narrow, elongate ventral cirri about half as long as ventral cirri of subsequent segments. Dorsal cirri present from segment 3, narrow ovoid with rounded tips, as long as neuropodial lobes on anterior segments; slightly broader, asymmetrical and slightly exceeding length of neuropodia to segment 40–50. Dorsal cirri narrower but of similar relative length posteriorly. Neuropodial lobes prominent from segment 2, with blunt rounded tips, narrower on posterior segments. Ventral cirri narrow, elongate, exceeding length of neuropodia on anterior 10–15 segments, thereafter as long as neuropodia on median segments and reducing to small lobe shorter than neuropodia posterior to about segment 70 (figs 5h, i). Anal cirri digitiform with rounded tips, 3 or 4 times as long as wide (fig. 5g). Setae with 2 unequal large teeth and apparently many small teeth (SEM preparations proved unsatisfactory).

Remarks. McIntosh (1908) subsequently reduced *Eteone robertianae* to the status of a variety of *E. arctica* (treated here as a junior synonym of *E. longa*), however the narrower dorsal cirri and longer anal cirri distinguish *E. robertianae* from the latter species. McIntosh (1908) also noted that two nuchal papillae were visible; I can see only one on the holotype. In addition, *Eteone robertianae* differs from all species of *Eteone* in having the first and second segments strongly constricted (this observation was confirmed by McIntosh's (1908) examination of additional material).

Eteone robertianae has longitudinal folds of the proboscis in the retracted position resembling the longitudinal ridges otherwise found only in species

of *Hypereteone*. This however appears to be an artefact of retraction; the folds are hollow, not thick and tuberculate and I would expect the proboscis to have a uniform rugose appearance without longitudinal ridges if specimens were preserved with this structure fully everted. In any case, the digitiform anal cirri clearly place this species in the genus *Eteone*, not *Hypereteone*.

Distribution. Recorded only from St Andrews, Scotland.

Eteone sculpta Ehlers

Figures 6a–c, 14c

Eteone sculpta Ehlers, 1897: 33–35, pl. 1 figs 26–33. South Georgia. – Augener, 1932: 26. South Georgia.

Eteone rubella Ehlers, 1900: 211. Santa Cruz, Patagonia (fide Augener, 1932).

Material examined. South Georgia, v.d. Steinen, HZM V-1205, labelled "original", *E. sculpta* holotype, SEM stub NMV F53930 segment 28 RHS parapodium.

Description. Holotype an entire specimen of 67 segments, 16 mm long, 1.5 (2.2) mm wide. Prostomium semi-circular, without dorsal groove or any obvious markings. Antennae inserted in notches at anterior margin of prostomium. Prostomium third to half as long as wide, width at anterior margin two-thirds that at posterior margin. No eyes visible. A distinct mid-dorsal depression present at posterior margin of prostomium but no nuchal papilla visible (fig. 6a). Proboscis (which had already been removed from holotype but not previously dissected to reveal structure) smooth, with pair of large lateral papillae and ring of smaller papillae at buccal opening. Tentacular cirri short and similar in length, only slightly longer than antennae. Second segment with setae, neuropodia and ovoid ventral cirri twice as long as neuropodium. Dorsal cirri present from segment 3, almost circular in shape except for region of attachment. Dorsal cirri equal in size to ventral cirri on anterior 10 segments, becoming relatively larger on median segments so that dorsal cirri are twice as long as neuropodia over segments 20–50; all parapodial lobes becoming reduced and similar in size on posterior-most segments. Neuropodia and ventral cirri equal in size from segment 3, neuropodia triangular with rounded tip, ventral cirri acuminate-lanceolate (fig. 6c). Anal cirri spherical globes 0.25 mm in diameter (fig. 6b). Setae with pair of large teeth of equal size and 3 or 4 tiers of small teeth (fig. 14c).

Remarks. Ehlers' (1897) description was based on a single specimen which agrees with that described above in all respects except number of segments (66 as against 74 counted by Ehlers); I presume this to be a minor error on Ehlers' part and regard this specimen as the holotype.

Eteone crassifolia Ehlers, 1900, (from Puerto Harris, Strait of Magellan), and *Eteone revi* Gravier, 1906, (from Antarctic seas) were listed as junior synonyms of *E. sculpta* by Hartman (1959) but without citing any authority.

Distribution. Recorded from South Georgia and Patagonia, southern Atlantic.

Eteone spetsbergensis Malmgren

Figures 6d–g, plate 2a

Eteone spetsbergensis Malmgren, 1865: 102, pl. 15 figs 38a–e. Spitsbergen. – Hartman, 1948: 20, fig. 5b. Bering Sea, Alaska.

Eteone spetsbergensis spetsbergensis. – Uschakov, 1974: 168. (synonymy).

Eteone spetsbergensis bistriata Uschakov, 1953: 208, 209, fig. 2. – Uschakov, 1974: 168, 169, pl. 17 figs 1–5. (synonymy).

Material examined. Svalbard (Spitsbergen), Shoal Point, 25–30 fm [46–55 m], A.S. Malmgren, SMNH 2412, 11 syntypes of *E. spetsbergensis*, SMNH SEM stub segment 11 RHS parapodium.

Description. The syntype series consists of 11 specimens and 2 median fragments, size range 85 segments, 38 mm long, 1.5 (2.0) mm wide (anterior fragment) to 166 segments, 78 mm long, 1.5 (2.0) mm wide (entire specimen). Colour in alcohol pale yellow, several specimens in poor condition. Prostomium as long as wide, truncate triangle with rounded anterior margin half as wide as posterior margin. Antennae half as long as width of anterior margin of prostomium. One pair of faint eyes visible in only 1 syntype. Nuchal papilla absent (fig. 6d). Proboscis fully everted in 1 syntype, 3 mm long and as long as 13 anterior segments, consisting of faintly tuberculate tube, widest at extremity, not divided into distinct regions. Buccal opening a fleshy ring without ring of papillae but with single pair of lateral papillae projecting from interior of orifice (fig. 6d). Tentacular cirri almost half as long as width of first segment, equal in length but ventral pair significantly stouter. Second segment with setae, asymmetrical kidney-shaped ventral cirri and strongly reduced neuropodia (setae of second segment few or occasionally absent in syntypes). Dorsal cirri present from segment 3, asymmetrical circular-ovoid over anterior segments, becoming more circular and symmetrical from about segments 40–50. Ventral cirri irregularly kidney-shaped, similar in length to dorsal cirri anteriorly,

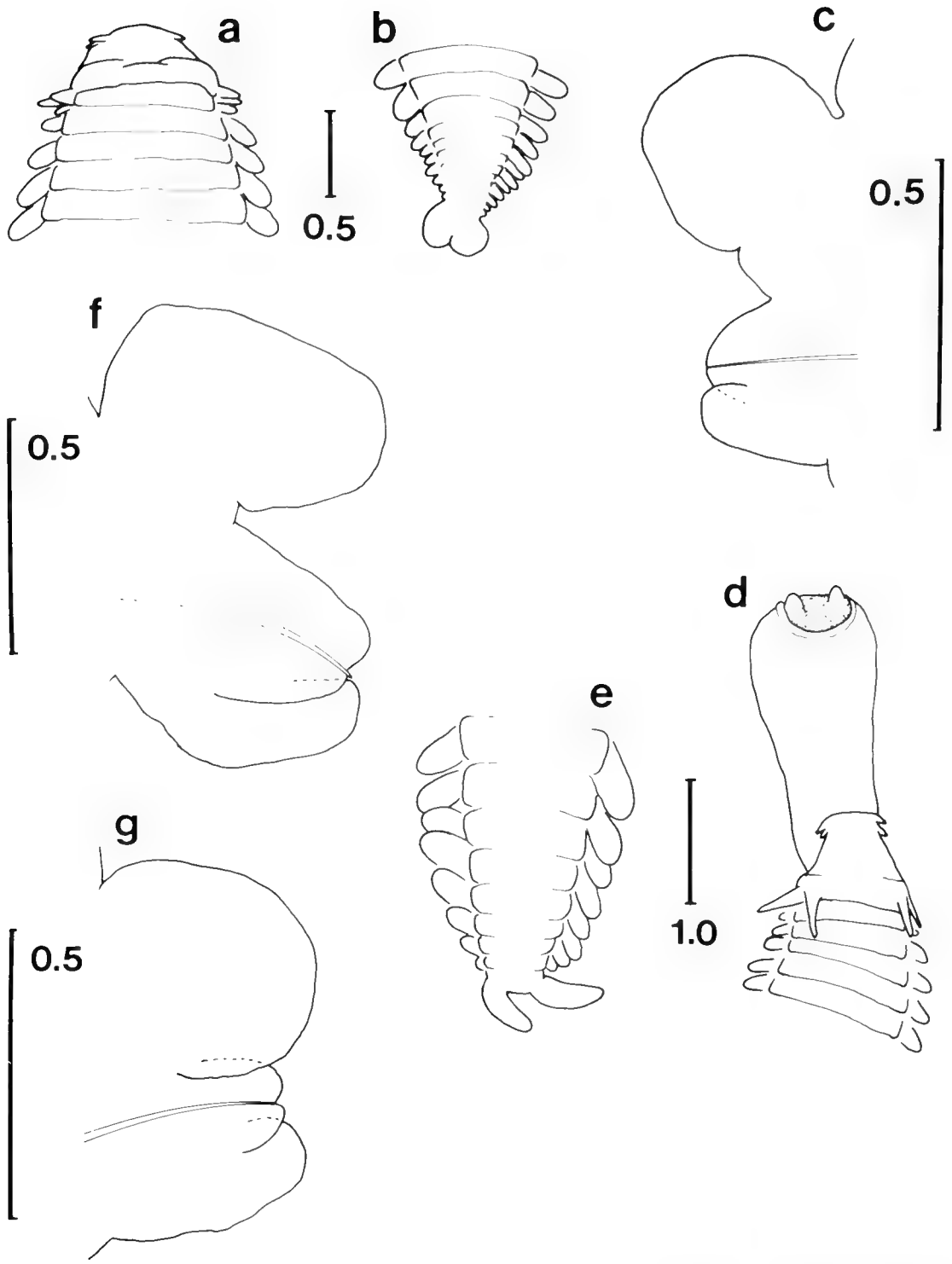

Figure 6. a–c, *Eteone sculpta* HZM V-1205 holotype: a, prostomium dorsal view; b, anal cirri; c, setiger 30 parapodium anterior view. d–g, *Eteone spetsbergensis* SMNH 2412 syntype: d, prostomium and everted proboscis dorsal view; e, anal cirri; f, setiger 20 parapodium posterior view; g, setiger 140 parapodium posterior view. Scale bars in mm.

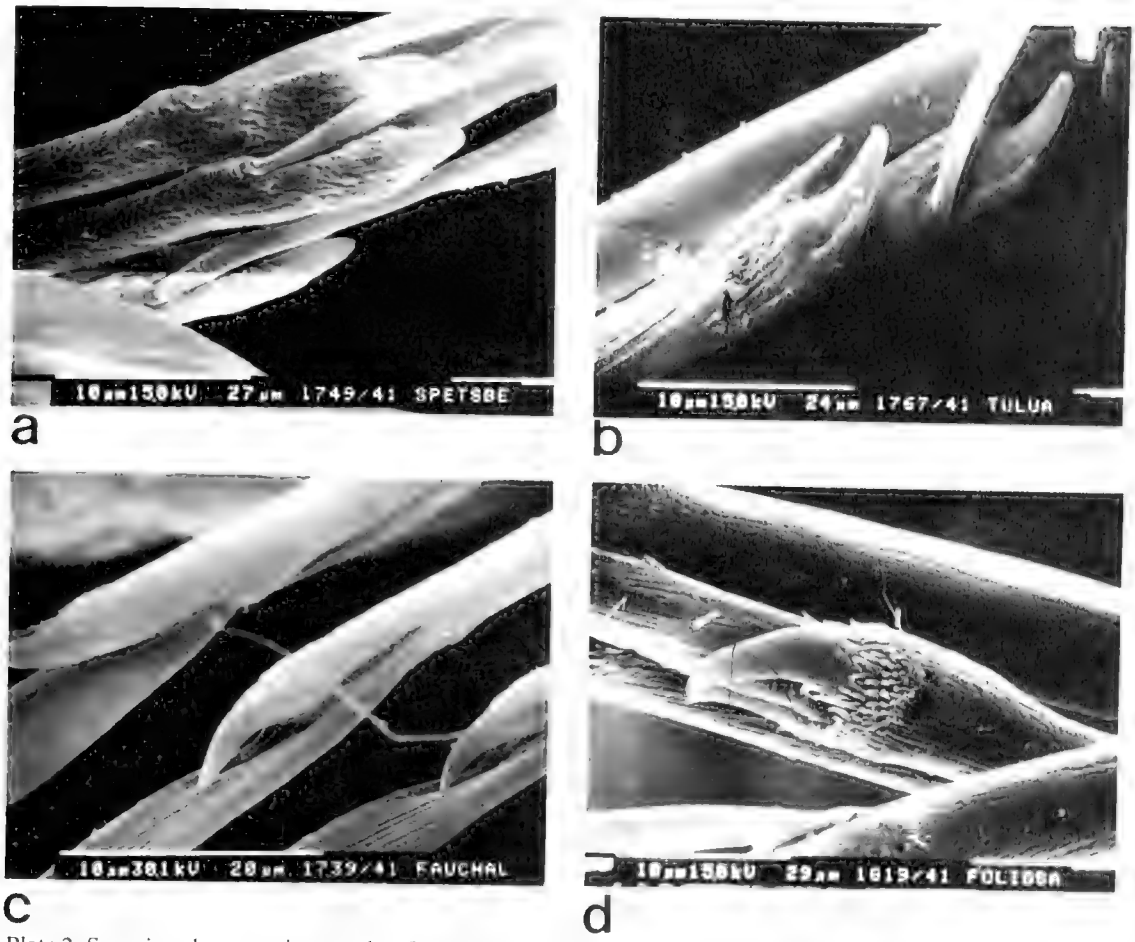

Plate 2. Scanning electron micrographs of setae of species of *Eteone* and *Hypereteone*. a, *E. spetsbergensis* SMNH 2412 syntype (from setiger 10); b, *E. tulua* QM GH3617 holotype (from setiger 10); c, *H. fauchaldi* USNM 579551 paratype (from setiger 10); d, *H. foliosa* MNHN unregistered, from Tatihou, near type locality (from setiger 190). Scale bars in μm.

dorsal cirri increasing further in size and exceeding length of ventral cirri from about segments 40–50. Lanceolate neuropodia as long as ventral cirri over most segments but shorter than ventral cirri over anterior-most 10 and posterior-most 20 segments (figs 6f, g). Anal cirri digitiform with narrow point of attachment, 3 times as long as wide (fig. 6e). Setae with 2 very dissimilar teeth and many smaller teeth in 4 or 5 tiers (pl. 2a).

Remarks. Eteone spetsbergensis is similar to *Eteone flava* but is distinguished by the strongly asymmetrical ear-shaped dorsal cirri in anterior segments, the longer anal cirri, and the setae with two unequal teeth. *Eteone andreapolis* McIntosh, 1874 (from St Andrews, Scotland) and *E. picta* Ehlers, 1873 (junior homonym, not Quatrefages, 1865) were listed by Hartman (1959) as junior synonyms of *E. spetsbergensis*. Uschakov (1974) recognised two subspecies based on differences in colouration.

Distribution. North Atlantic (north from Scotland) and Arctic Oceans (after Uschakov, 1974).

Eteone spilotus Kravitz and Jones

Figures 7a-d, 14f

Eteone spilotus Kravitz and Jones, 1979: 9, 10, figs 3a–c. Columbia River, west coast USA.

Material examined. USA, northern Oregon/southern Washington, off Columbia River, 46°14.0'N, 124°10.75'W, Stn 88A grab 5, 7 Dec 1974, 44 m, A. Carey, USNM 57959, 2 paratypes, SEM stub NMV F53931 segment 11 parapodium from larger of 2 paratypes.

Description. Size range of paratypes examined: 88

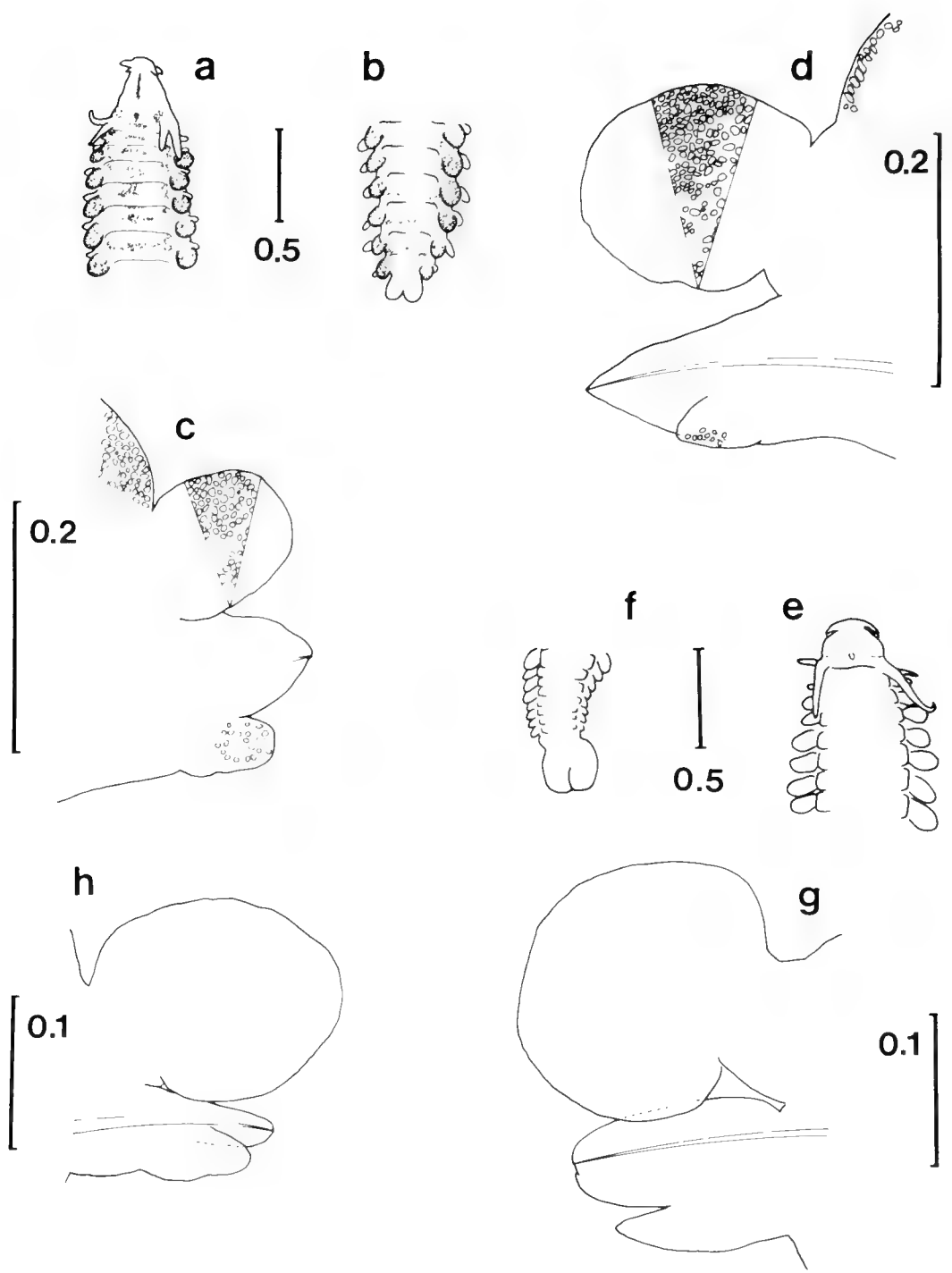

Figure 7. a–d, *Eteone spilotus* USNM 57959 larger of 2 paratypes: a, prostomium, dorsal view; b, anal cirri; c, setiger 10 parapodium posterior view; d, setiger 50 parapodium anterior view (stippling indicates areas of dark brown pigmentation; detail shows dark brown pigmented cells in dorsal cirri). e–h, *Eteone trilineata* USNM 441 largest of 3 syntypes: e, prostomium dorsal view; f, anal cirri; g, setiger 11 parapodium anterior view; h, setiger 50 parapodium posterior view. Scale bars in mm.

segments, 13 mm long, 0.4 (0.6) mm wide; 122 segments, 18 mm long, 0.5 (0.7) mm wide (entire worms). Colour in alcohol pale yellow with conspicuous dark brown pigmentation: prostomium with median longitudinal lines dorsally and ventrally and lateral patch on each side, dorsal and anal cirri heavily pigmented, ventral cirri sparsely pigmented and each segment with heavily pigmented transverse band dorsally and ventrally and patch at base of each dorsal cirrus (fig. 7a). Prostomium about as long as maximum width at posterior margin, width at anterior margin half width at posterior margin. Anterior margin rounded, with blunt antennae each third–half as long as anterior width of prostomium. One pair of dark red subdermal eyes near posterior margin of prostomium. Prostomium with median dorsal groove and nuchal papilla on the posterior margin (fig. 7a). Proboscis, examined through ventral dissection in larger of 2 paratypes, extends back to segment 6, folded internally to produce about 4 hollow longitudinal ridges, otherwise smooth. Buccal opening with 2 large lateral papillae and uncertain number of smaller papillae in a ring. Tentacular cirri third as long as width of first segment. Second segment with setae, rounded digitiform neuropodia and ventral cirri of similar length. Dorsal cirri present from segment 3, quadrangular with rounded corners over first 10 segments, becoming more rounded and narrower at base thereafter. Neuropodia becoming narrower and acuminate and ventral cirri reduced to small digitiform process from segments 40–50 (figs 7c, d). No significant change to proportions of subsequent segments. Anal cirri 3 times as long as wide and equal to posterior-most 2 segments in length (fig. 7b). Setae with 2 pairs of similarly-sized large teeth and many small teeth in 2 or 3 tiers (fig. 14f).

Remarks. Kravitz and Jones (1979) reported that the everted proboscis is smooth; the hollow internal folds noted above are most probably an artefact of retraction and are not comparable with the thick tuberculate or rugose ridges seen in species of *Hypereteone*. With the aid of SEM, the setae are seen to have two teeth of equal or nearly equal size on each side of the blade, further distinguishing *Eteone spilotus* from *E. californica* and similar species.

Distribution. Northern Oregon and southern Washington, west coast of USA.

Eteone suecica Bergström

Eteone suecica Bergström, 1914: 199–201, figs 75a–e. West coast of Sweden.

Remarks. Bergström's type material is apparently lost (F. Pleijel, pers. comm.). The following is abstracted from Pleijel (in prep.): Prostomium broader than long, ventral pair of antennae longer than dorsal pair. One pair of eyes and nuchal papilla present but indistinct in preserved specimens. Proboscis finely rugose proximally, distally smooth, the 2 regions separated by furrow; without terminal ring of papillae but with pair of large lateral papillae inside orifice. Tentacular cirri about as long as width of first segment, ventral pair stouter. Dorsal cirri rounded, situated on prominent cirrophores. Ventral cirri with acutely pointed tips, longer than neuropodial lobes. Anal cirri as long as broad. Setae with pair of large teeth of equal size and few small teeth.

Distribution. Known only from north-east England and Sweden (Pleijel, in prep.).

Eteone tetraophthalma Schmarda

Eteone tetraophthalma Schmarda, 1861: 85, figs a–d. Atlantic Ocean.

Remarks. The location of Schmarda's type material is unknown. *Eteone tetraophthalma* is poorly known; Schmarda's description includes the following information: 4 eyes, anterior pair closer together and larger than posterior pair; 2 pairs of tentacular cirri of unequal length; dorsal cirri lanceolate, longer than neuropodial lobes; anal cirri lanceolate. No other species of *Eteone* is known to possess four eyes. Schmarda's description of lanceolate anal cirri and tentacular cirri of unequal length indicates that *E. tetraopthalma* may be a species of *Hypereteone*, but there is insufficient information to make a new combination and this species is provisionally retained in *Eteone*.

Distribution. Recorded by Schmarda from the Atlantic Ocean.

Eteone trilineata Webster and Benedict

Figures 7e–h, 14g

Eteone trilineata Webster and Benedict, 1887: 712, pl. 1 figs 5–8, pl. 2 fig. 9. Maine.—Pettibone, 1963: 71–72, fig. 16g.

Material examined. USA, Maine, Eastport, coll. H.E. Webster, no date, USNM 441, 3 syntypes, SEM stub NMV F53932 segment 12 RHS parapodium from largest of 3 syntypes.

Description. Size range of syntypes 62 segments, 4 mm long, 0.3 (0.5) mm wide to 76 segments, 8 mm long, 0.4(0.6) mm wide (all entire specimens). Prostomium 1.3 times wider than long, lateral margins convex and bulbous, narrow only in extreme

anterior region which is separated by distinct constriction. Anterior margin half width of posterior margin. Antennae about half as long as anterior width of prostomium (fig. 7e). Eyes not visible (a single pair of large black eyes situated close to posterior margin of prostomium was figured by Webster and Benedict; these have apparently faded since). Prostomium opaque and colourless but with 4 distinct transparent regions: 1 in median anterior region and another immediately posterior to the first, and pair posteriorly on lateral margins. Prostomium with median nuchal papilla on posterior margin. Proboscis, examined through ventral incision on largest syntype, extends back to segment 13, details unclear in dissection but appears slightly rugose basally with large irregular papillae in indistinct dorsolateral region distally, with ring of 10 or more papillae at buccal opening. Ventral pair of tentacular cirri as long as width of first segment, dorsal pair twice as long and with very fine tip section (third of total length of cirrus). Second segment with setae, lanceolate neuropodia and similar but slightly longer ventral cirri. Neuropodia and ventral cirri similar in size from segment 10 and of similar prortions throughout. Dorsal cirri present from segment 3, circular, anteriorly similar in size to neuropodia but from segments 8–10 exceeding length of other parapodial lobes and present as large lamellar lobe attached to distinct basal stalk throughout all posterior segments (figs 7g, h). Anal cirri stout, digitiform, about 3 times as long as wide and as long as last 3 or 4 segments (fig. 7f). Setae with pair of large teeth of similar size and about 8–10 small teeth in 2 tiers (fig. 14g).

Distribution. Recorded from Gulf of St Lawrence to Massachusetts, east coast USA (Pettibone, 1963).

Eteone tuberculata Treadwell

Eteone tuberculata Treadwell, 1922: 174. Washington. – Banse, 1972: 193, 194, fig. 1g–l (redescription).

Remarks. The following is taken from the original description of Treadwell (1922) and from Banse's (1972) redescription of the holotype. Prostomium about as long as wide with narrow rounded anterior margin. Prostomium forming median dorsal indentation into first segment carrying distinct nuchal tubercule. Tentacular cirri equal in length. Proboscis apparently absent and unknown. Right parapodium of second segment removed by Treadwell and described with setae and an aciculum; left parapodium of second segment remains and was described by Banse as lacking setae and with reduced neuropodium. Dorsal cirri symmetrical, conical-lanceolate, becoming narrower on posterior segments, roughly as long as neuropodial lobes throughout. Ventral cirri lanceolate, as long as neuropodia anteriorly, shorter posteriorly. Anal cirri described as "short, stout" by Treadwell, and "conical" by Banse. Setae apparently with two unequal teeth anteriorly, teeth equal in size on median and posterior segments.

Distribution. Known only from Friday Harbour, Washington State, west coast of North America.

Eteone tulua sp. nov.

Figures 8a–d, plate 2b

Material examined. Holotype: Australia, Queensland, Middle Banks, northern Moreton Bay, Nov 1983–Nov 1984, coll. P. Saenger and S. Cook, QM GH3617, SEM stub NMV F53933 segment 11 parapodium.

Paratypes: Queensland, Calliope River, Gladstone, east bank of river, 2.2 m, coarse sand, 1976–1977, van Veen Grab, P. Saenger, AM W19157, 1 paratype; Calliope River, Gladstone, transect 9 on anabranch of Calliope River, 4.1 m, mud, 1976–1977, van Veen Grab, P. Saenger, AM W19158, 1 paratype, SEM stub NMV F53934 4 posterior-most segments.

Description. Holotype an entire specimen, 88 segments, 10 mm long, 0.6 (0.8) mm wide at segment 10. Size range of paratypes: 107 segments, 17 mm long, 0.4 (0.7) mm wide and 134 segments, 23 mm long, 0.6 (0.9) mm wide (anterior fragments, 1 regenerating posteriorly). Body pale yellow, pigment patterns absent except for posterior half of prostomium which is diffusely pigmented brown-black. Prostomium strongly dorso-ventrally flattened, about as long as wide, anterior margin rounded and only very slightly narrower than posterior margin. Prostomium rounded anteriorly and with small but distinct median indentation of anterior margin. Antennae about three-quarters as long as width of anterior margin of prostomium. One pair of large black eyes located close to posterior margin of prostomium, no nuchal papilla (fig. 8a). Proboscis (examined in ventral dissection) extends back to segment 14, smooth over proximal half but with internal fold producing hollow dorsal ridge. Distal half of proboscis covered with coarse rugose papillae, papillae finer and more sparse in dorsal region, larger laterally and ventrally. Buccal opening with pair of large lateral papillae and ring of 10 of more smaller papillae. First segment enlarged laterally, narrower dorsally. Dorsal pair of tentacular cirri approximately as long as width of first segment, ventral pair slightly shorter and stouter. Second segment with setae, ovoid ventral

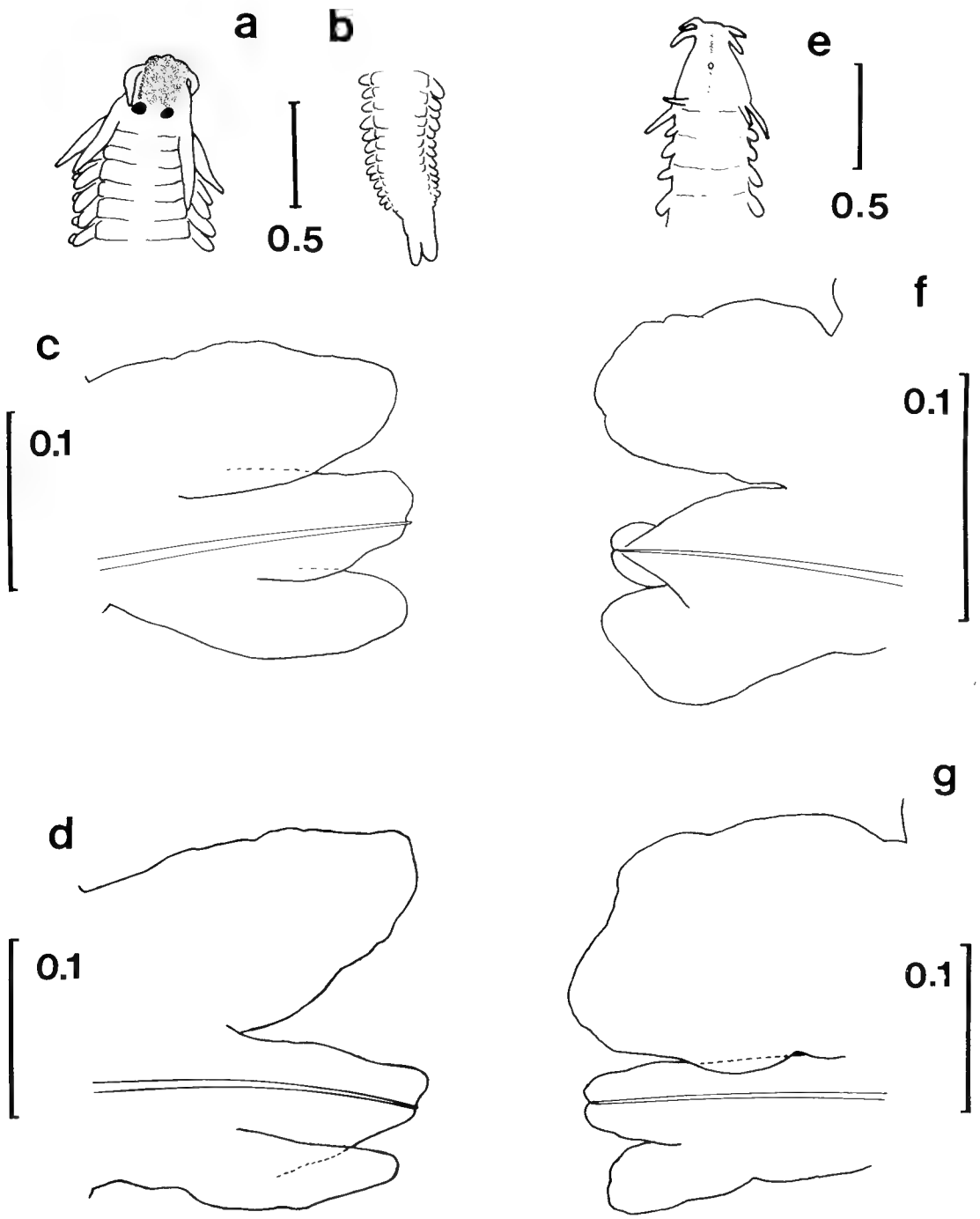

Figure 8. a–d, *Eteone tulua* QM GH3617 holotype: a, prostomium dorsal view (stippling shows area of brown-black pigmentation); b, anal cirri; c, setiger 11 parapodium posterior view; d, setiger 50 parapodium posterior view. e–g, *Hypereteone alba* USNM 493 lectotype: e, prostomium dorsal view; f, setiger 10 parapodium anterior view; g, setiger 92 parapodium anterior view. Scale bars in mm.

cirri and smaller digitiform neuropodia. Ovoid-lanceolate dorsal cirri present from segment 3, as long as other lobes and similar throughout all posterior segments. Neuropodia triangular and ventral cirri lanceolate on anterior segments and of equal length throughout but both becoming narrower posteriorly; ventral cirri cirriform over posterior-most 30 or more segments (figs 8c, d). Anal cirri digitiform, about 4 times as long as wide (fig. 8b). Setae with single large curved tooth and 2 or 3 smaller teeth (pl. 2b).

Remarks. *Eteone tulua* differs from all other species of *Eteone* in having the prostomium about as long as its maximum width and the dorsal tentacular cirri longer than the ventral. The distinctive setae of *E. tulua* which have only two or three small teeth at the base of a single large tooth are unlike any other species of *Eteone*, however this character can only be seen clearly in material examined under SEM.

Etymology. The specific name *tulua* is derived from the name of an Aboriginal tribe whose territory included the Calliope River, Queensland, and is to be treated as indeclinable.

Distribution. Known from Moreton Bay and the Calliope River, south-eastern Queensland, Australia.

Eteone vitiazi Uschakov

Eteone vitiazi Uschakov, 1974: 169, pl. 18 figs 8–10. East of Honshu, North Pacific, 5475 m.

Remarks. The following information is taken from Uschakov (1974): Prostomium longer than wide, antennae large. No eyes or nuchal papilla visible. Proboscis retracted, possibly with lateral papillae. Ventral tentacular cirri much longer and stouter than dorsal pair. Second segment with setae, neuropodia and ventral cirri. Dorsal cirri ovoid, twice as long as wide. Neuropodial lobes much longer than ventral cirri, from segment 25 almost as long as width of body. Setae with large teeth very dissimilar in size. Anal cirri not described.

Uschakov suggested that if the presence of lateral rows of papillae was verified, *E. vitiazi* may have to be transferred to the genus *Mysta*. The proportions of the prostomium and tentacular cirri are similar to species of *Hypereteone* as defined in this paper and are unlike any species of *Mysta*. Examination of the proboscis and anal cirri is required to verify the generic placement of *E. vitiazi*.

Distribution. Known only from the original description, east of Honshu, North Pacific Ocean, 5475 m depth.

Genus **Hypereteone** Bergström, 1914, emended

Diagnosis. Phyllodocidae with 2 pairs of antennae, 2 pairs of tentacular cirri on the first segment. Second segment lacking dorsal cirri. Eversible proboscis with 3 or more longitudinal rugose ridges or rows of tuberculae. Anal cirri long, tapering to fine pointed tip.

Type species. *Eteone lactea* Claparède, 1868, by monotypy.

Remarks. Whether or not the proboscis is described as consisting of rugose ridges or rows of distinct tuberculae depends to some extent on the state of contraction and preservation of the proboscis, but also varies between species. Thus *Hypereteone heteropoda* and *H. lighti* have rugose ridges but lack the distinct rows of tuberculae which are present in *H. foliosa* and most remaining species. I consider that the distinctive cirriform anal cirri represent the major generic character; the presence of numerous longitudinal ridges or rows of tuberculae in all species is further evidence that this group of species represents a monophyletic taxon within *Eteone* sensu lato of authors such as Pleijel (in prep.). Bergström's original definition was based on the absence of setae from the second segment; in this study the structure of the proboscis and anal cirri is given more weight and an emended generic diagnosis is provided. Only four of nine species of *Hypereteone* described here lack setae on the second segment, and even among these species *H. foliosa* exhibits some apparently size-related variability in this character (see Remarks under the species account for *H. foliosa*). Material is too scarce to determine if absence of setae on anterior segments is a variable character in other species of *Hypereteone*.

The critical generic characters unfortunately are often difficult to determine since the proboscis is a challenge to dissect in small specimens and much material is incomplete posteriorly and thus anal cirri will frequently be lost. Many (but not all) species of *Hypereteone* have ventral tentacular cirri much longer than the dorsal tentacular cirri and the first segment often appears to be partly fused to the prostomium; these characters may be sufficient to indicate generic placement until better material comes to hand.

Key to species of *Hypereteone*

The key includes all 9 named species recognised here; *Hypereteone* sp. (see systematic account below) is excluded due to the limited description.

1. Setae present on segment 2 2
— Setae absent on segment 2 6
2. Maximum width of prostomium exceeding length 3
— Prostomium as long or longer than maximum width 5
3. Ventral cirri much smaller than neuropodial lobe ..... *H. barantollae*
— Ventral cirri and neuropodial lobe similar in length, at least on most anterior and median segments 4
4. Ventral tentacular cirri much longer than dorsal; setae with 2 large unequal teeth and many small teeth ..... *H. heteropoda*
— Ventral tentacular cirri only slightly longer than dorsal; setae with 2 large equal and few small teeth ..... *H. lighti*
5. Ventral tentacular cirri twice a long as dorsal; dorsal cirri expanded on posterior segments ..... *H. aesturina*
— Ventral tentacular cirri only slightly longer than dorsal; dorsal cirri not expanded posteriorly ..... *H. fauchaldi*
6. Prostomium twice as long as maximum width ..... *H. tingara*
— Prostomium about as long as maximum width 7
7. Setae with only 1 conspicuous large pointed tooth; ventral tentacular cirri 1.5 times as long as dorsal tentacular cirri ..... *H. otati*
— Setae with 2 unequal teeth, largest tooth with blunt rounded tip; ventral tentacular cirri 2 to 2.5 times as long as dorsal ..... *H. alba*
— Setae with 2 unequal pointed teeth; ventral tentacular cirri 1.5 times as long as dorsal ..... *H. foliosa*

Hypereteone aesturina (Hartmann-Schröder) comb. nov.

Eteone aesturina Hartmann-Schröder, 1959: 98–101, figs 26-30. El Salvadore.

Remarks. The following summary of important taxonomic characters is taken from Hartmann-Schröder (1959). Prostomium longer than maximum width, with 2 pairs of antennae longer than anterior width of prostomium. Ventral pair of tentacular cirri twice as long as dorsal pair of tentacular cirri. No distinct division between first segment and prostomium. Second segment with setae. Dorsal and ventral cirri ovoid, similar in length anteriorly, dorsal cirri expanded on posterior segments. Neuropodial lobes shorter than ventral cirri. Setae with 2 unequal teeth. Anal cirri long, tapering to a fine point. Proboscis not described.

Hartmann-Schröder's description is sufficient to place this species in the genus *Hypereteone* as defined above.

Distribution. El Zapote, El Salvadore.

Hypereteone alba (Webster) comb. nov.

Figures 8e–g; 14h

Eteone alba Webster, 1879: 134, 135, pl. 2(5) figs 13–16 (in part).

Material examined. USA, New Jersey, Great Egg Harbour, coll. H.E. Webster, USNM 493, lectotype and 2 paralectotypes (not conspecific; see below) and 2 SEM stubs, NMV F53935 segment 11 parapodium from lectotype; NMV F53936 segment 11 parapodium from larger of 2 paralectotypes.

Description. Based on the lectotype, an anterior fragment of 116 segments, 20 mm long, 0.4(0.7) mm wide at segment 11. Colour in alcohol pale yellow-white. Prostomium as long as wide, width at anterior margin half that of posterior margin. Antennae small, about as long as anterior width of prostomium. A deep median dorsal groove extends from anterior margin of the prostomium back to segment 4. An indistinct nuchal papilla appears to be present on posterior section of prostomium. No eyes visible (fig. 8e). Proboscis, examined through ventral dissection, extends back to segment 10, with indistinct longitudinal ridges and terminal ring of about 12 papillae. Ventral pair of tentacular cirri 2–2.5 times as long as dorsal pair. Second segment with very small ventral cirri; neuropodia and setae absent. Third segment with setae, ovoid-lanceolate dorsal cirri, neuropodia and ventral cirri, all similar in size on anterior segments. Dorsal cirri ovoid throughout, becoming expanded by segments 20–30 and reaching maximum size by

segments 50–60 where dorsal cirri about 1.5 times as long as ventral cirri and neuropodia. All parapodial lobes slightly smaller on posterior segments but proportions remaining similar; ventral cirri and neuropodia equal in size throughout (figs 8f, g). Anal cirri unknown. Setae with pair of very unequal teeth, large tooth rounded, and several slightly smaller teeth (fig. 14h).

Remarks. The lectotype, designated in this study, is not conspecific with the paralectotypes; the differences are summarised in Table 1. The paralectotypes also clearly belong in the genus *Hypereteone* as defined here as they have probosces with longitudinal rugose ridges and long cirriform anal cirri, however despite some similarities with *H. heteropoda* and *H. lighti* I am not confident of a specific identification.

Hypereteone alba is placed in the genus *Hypereteone* on the basis of the longitudinal ridges on the proboscis, the strongly unequal tentacular cirri and the absence of setae and neuropodia on the second segment. The presence of long cirriform anal cirri should be confirmed when more material of *H. alba* is examined.

Distribution. The only confirmed record is the lectotype, from Great Egg Harbour, New Jersey, USA.

Hypereteone barantollae (Fauvel) comb. nov.

Eteone barantollae Fauvel, 1932: 72, 73, figs 13a–d. Near Calcutta, India.

Remarks. The following brief description is taken from Fauvel (1932). Prostomium broader than long, with 1 pair of small black eyes. Antennae knob-like. Proboscis smooth basally, with 5 longitudinal rows of papillae anteriorly. Ventral pair of tentacular cirri longer than dorsal pair. Second segment with setae, neuropodia and ventral cirri. Dorsal cirri present from segment 3, ovoid to rounded, approximately symmetrical and carried on distinct cirrophore. Neuropodia and ventral cirri ovoid, ventral cirri much shorter than neuropodia. Anal cirri foliaceous, lanceolate. Setae not described.

Fauvel's original description clearly places this species in the genus *Hypereteone* as redefined above.

Distribution. Near Calcutta, India.

Hypereteone fauchaldi (Kravitz and Jones) comb nov.

Figures 9a–e; plate 2c

Eteone fauchaldi Kravitz and Jones, 1979: 7–9, figs 2a–g. Columbia River, west coast USA.

Material examined. USA, northern Oregon and southern Washington, off Columbia River mouth, 46°14.5'N, 124°10.5'W, Stn 16C, 33 m, 21 Apr 1975, coll. A. Carey, USNM 57955, 1 paratype, SEM stub NMV F53937 segment 11 parapodium.

Description. A single paratype, 127 segments, 20 mm long, 0.4 (0.6) mm wide. Prostomium trape-

Table 1. Comparison of *Hypereteone alba* lectotype and paralectotypes (USNM 493)

Lectotype	Paralectotypes
anterior margin of prostomium = half width of posterior margin	anterior margin of prostomium = ⅓–⅕ width of posterior margin
retracted proboscis extends back 9 setigers	retracted proboscis extends back 3–6 setigers
ventral tentacular cirri longer than dorsal tentacular cirri	dorsal and ventral tentacular cirri equal in length
neuropodia and setae absent from second segment	second segment with neuropodia and many long setae
setae with pair of teeth very unequal in size (fig. 14h)	setae with pair of large teeth similar in size (fig. 14i)

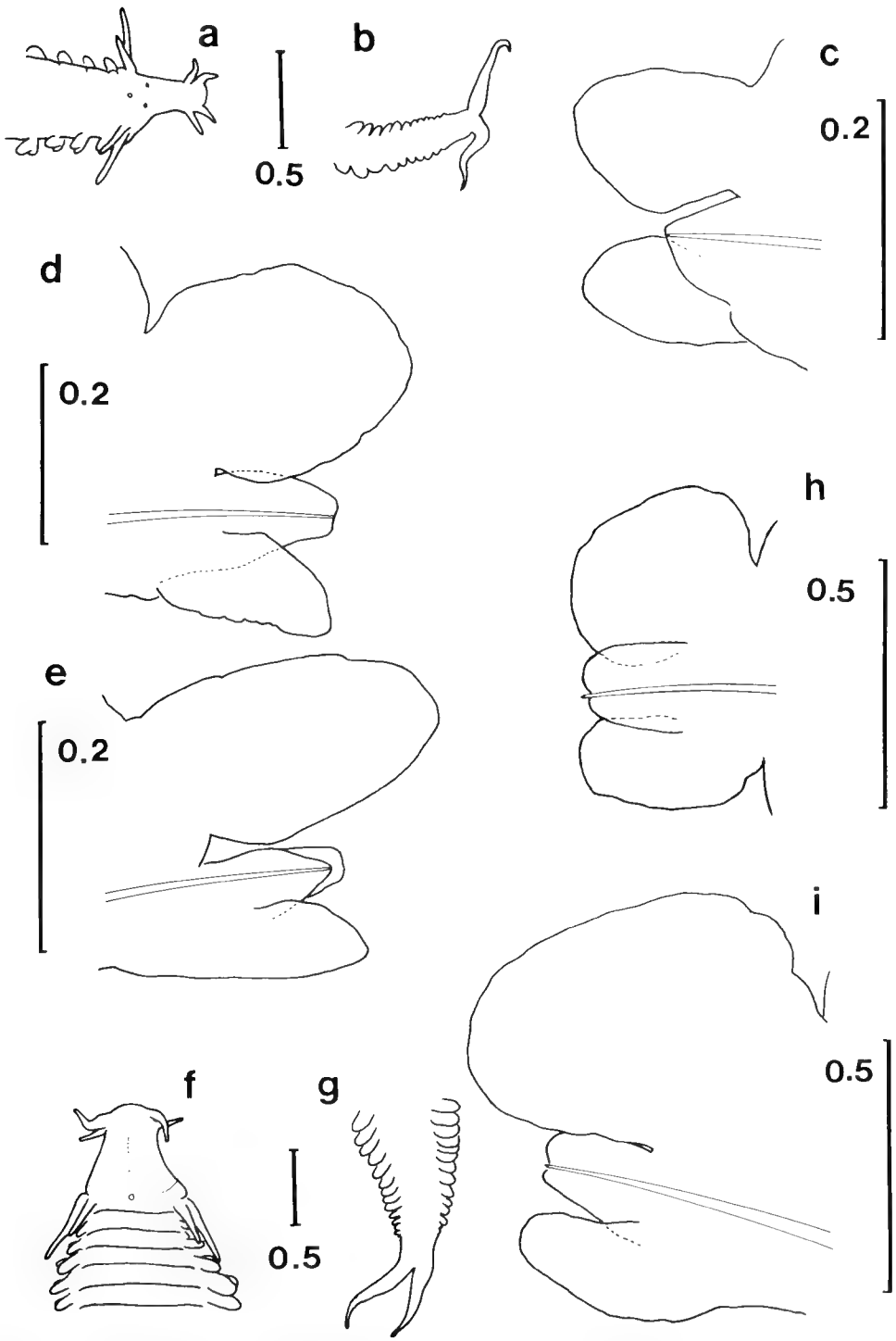

Figure 9. a–e, *Hypereteone fauchaldi* USNM 57955 paratype: a, prostomium dorsolateral view; b, anal cirri; c, setiger 10 parapodium anterior view; d, setiger 50 parapodium posterior view; e, setiger 100 parapodium posterior view. f–i, *Hypereteone foliosa* MNHN unregistered: f, prostomium dorsal view; g, anal cirri; h, setiger 21 parapodium anterior view; i, setiger 189 parapodium anterior view. Scale bars in mm.

zoid, 2.5 times as long as wide, anterior margin half width of posterior margin. Antennae as long as anterior width of prostomium. Dorsal pair of antennae located at lateral anterior extremities of prostomium, second pair slightly posterior and ventral to first. One pair of faint red subdermal eyes, widely spaced, close to posterior margin of prostomium. Nuchal papilla on posterior margin (fig. 9a). Proboscis, examined through ventral dissection, extends back to 11th segment, with a a rugose dorsal band becoming more tuberculate distally; elsewhere smooth. Ventral pair of tentacular cirri as long as width of first segment, dorsal pair narrower and slightly shorter. Second segment with only a few setae, neuropodia and lanceolate ventral cirri. Dorsal cirri present from segment 3, ovoid in shape and of similar length to ventral cirri over anterior 50 segments. Dorsal cirri becoming substantially larger than ventral cirri and neuropodia on posterior segments. Ventral cirri lanceolate and acuminate throughout, up to twice as long as neuropodia on anterior segments, reducing posteriorly and as long as neuropodia from segment 50 (figs 9c–e). Anal cirri stout and fleshy basally, tapering to fine point, as long as last 6–8 segments (fig. 9b). Setae with single long curved tooth and several smaller teeth in 2 or 3 tiers (pl. 2c).

Remarks. The prostomium of the paratype examined here is slightly more elongate than that of the specimen figured by Kravitz and Jones (1979). The description of the probosces differs slightly also: Kravitz and Jones described the proboscis as tuberculate, whereas the proboscis of paratype USNM 57955 is apparently tuberculate only in a dorsal band; the discrepancy may be due to the difficulty of dissecting this small structure. The description above otherwise agrees with the original.

Hypereteone foliosa (Quatrefages) comb. nov.

Figures 9f–i; plate 2d

Eteone foliosa Quatrefages, 1865: 146, 147. France.
Eteone pusilla. – Malmgren, 1865: 102, pl. 15 figs 37a–d (not Ørsted, 1843).

Material examined. Scandinavia, Bohuslan (= "Bahusia" in Malmgren, 1865), coll. S. Loven, SMNH 5952, 4 specimens (material identified as *E. pusilla* by Malmgren, 1865).

France, Tatihou (near to St Vaast la Houge, east of Cherbourg, type locality), 1898, coll M. Gravier, MNHN unregistered, 100 + specimens, SEM stub NMV F53938 segment 21 RHS parapodium and segments 191, 192.

Morocco, "No. 10", 1903, coll M. Buchet, MNHN unregistered, 1 specimen (det. Fauvel 1942 as *E. lactea*).

Description. Size range of material examined: 256 segments, 66 mm long, 0.7(1.2) mm wide to 239 segments (regenerating posteriorly), 77 mm long, 1.2(1.6) mm wide. Colour in alcohol pale yellow-brown. Prostomium as long as wide, anterior margin rounded, half width of posterior margin, with median longitudinal dorsal groove. Eyes not visible. Anterior pair of antennae slightly shorter than second pair which are situated immediately posterior to first pair. A small but distinct nuchal papilla at posterior margin of prostomium (fig. 9f). Proboscis long and fully retracted in all specimens, extending back 26–29 segments, very narrow over basal three-quarters of its length, becoming much wider on its distal quarter. Internally with 6 longitudinal rugose ridges, dorsal row being 2 tuberculae wide, others comprised of single rows of irregular tuberculae. A terminal ring of 18 or more (22 or 23 according to Pleijel, in prep.) papillae and pair of large lateral papillae. Ventral pair of tentacular cirri about three-quarters as long as width of first segment, dorsal pair narrower and about three-quarters as long as ventral pair. Second segment with ovoid ventral cirri similar in size to those of subsequent segments, without neuropodia or setae. Third segment with setae, ovoid dorsal cirri as long as ventral cirri, and smaller triangular-lanceolate neuropodia. Dorsal cirri roughly circular in shape on anterior segments and asymmetrical, becoming asymmetrical and ovoid on posterior segments. Ventral cirri ovoid, slightly exceeding length of neuropodia on anterior and median segments. Ventral cirri becoming slightly reduced posteriorly, about as long as neuropodia from about segment 150. Neuropodia lanceolate lobe throughout with bifid tip divided by the tip of the aciculae which project slightly (figs 9h, i). Anal cirri stout basally, at least 6 times as long as wide, tapering to a fine point and as long as posterior-most 10–14 segments (fig. 9g). Setae with pair of large teeth unequal in length and 3 or 4 tiers of uniformly sized small teeth (pl. 2d).

Remarks. Hypereteone lactea Claparède, 1868, the type species of the genus, may be a junior synonym of *H. foliosa*, however there is no detailed description available of material from the type locality of *H. lactea* (Gulf of Naples). Bergström (1914) recorded *H. lactea* from the Mediterranean as well as the North Atlantic. Pettibone (1963) recorded *H. lactea* from the Atlantic coast of the USA however this material should be compared with the above description of *H. foliosa* and with the several related species from the USA described in this paper before such range extensions are

accepted. *Eteone caeca* Ehlers, 1874 from Galway, Ireland was synonymised with *H. foliosa* by Hartman, 1959 but without citing any authority. *Eteone malmgreni* Michaelsen, 1897 was introduced as a new name for material originally identified by Malmgren, 1865 as *E. pusilla* Ørsted; *E. malmgreni* Michaelsen, 1897 may also be a junior synonym of *Hypereteone lactea* as asserted by Hartman, 1959.

The above key to species of *Hypereteone* utilises the absence of setae from the second segment as a taxonomic character, however there may be some variability in this character, in *H. foliosa* at least: Eliason (1962) showed that some small specimens of *E. lactea* (presumably = *H. foliosa*) from the Öresund possess setae on one side of the second segment whereas all larger specimens were lacking setae on the second segment. F. Pleijel (pers. comm.) has also drawn my attention to variability in this character. Colour is also apparently variable: Pleijel (in prep.) describes the colour in life and preserved as cream-white whereas I have recorded the colour as pale yellow-brown (however, all specimens examined here have been stored in alcohol for over 80 years).

Distribution. Swedish west coast, North Sea, Atlantic coast of France, possibly Mediterranean Sea.

Hypereteone heteropoda (Hartman) comb. nov.

Figures 10a–e; plate 3a

Eteone heteropoda Hartman, 1951: 31–33, pl. 9 figs 1–8. Gulf of Mexico.

Material examined. USA, Florida: label reads: "n1820 Fla 3", AHF 0119, holotype and SEM stub NMV F53939 segment 11 RHS parapodium (Hartman's original description lists 2 Florida localities as sources of original material: Stingaree Flats, upper end of Lemon Bay, Jan 1938; and Ochlockonee Bay, Franklin Co., Mar 1950, coll. L.M. Henry). Mississippi, Deer Island, near Biloxi, Dec 1943, coll. M.W. Williams, USNM 21558, 3 paratypes and SEM stub NMV F53940 segment 11 parapodium.

Description. (from holotype). Holotype consisting of 2 fragments: anterior fragment 128 segments, 48 mm long, 1.2 (2.0) mm wide; posterior fragment carries anal cirri, 40 segments, 11 mm long. Prostomium a truncate triangle, slightly shorter than its maximum width at posterior margin. Width of prostomium at anterior margin third width at posterior margin. Antennae slightly shorter than anterior margin of prostomium. Anterior pair of antennae distally inserted on prostomium, second pair located immediately posterior to first. Antennae stout basally, tapering to very fine tip, appearing almost biarticulate. One pair of dark subdermal eyes, widely spaced, situated close to posterior margin of prostomium. Prostomium with median dorsal groove and minute dorsal papilla on posterior margin. Proboscis of holotype fully everted and as long as anterior 13 segments. Proboscis rugose with 8 distinct longitudinal ridges and ring of 20 fleshy papillae around bucal opening (fig. 10a). Dorsal pair of tentacular cirri thinner and two-thirds length of ventral pair. Second segment with setae, neuropodia and triangular ventral cirri about twice neuropodial length. Segment 3 with cirriform dorsal cirri and more numerous setae. Dorsal cirri lanceolate with rounded tip from segment 3, of similar length to neuropodia anteriorly, dorsal cirri becoming triangular acuminate, thick and fleshy from about segment 40, dorsal cirri longer than other parapodial lobes on posterior 30 segments. Neuropodia elongate-lanceolate throughout. Ventral cirri triangular with acuminate tip, gradually reducing in size posterior to segment 40, by about segment 60 reduced to a small triangular process attached to ventral margin of neuropodia (figs 10c-e). Body thick anteriorly, narrowing considerably and parapodia becoming longer and larger from segments 30–40. Anal cirri thick and fleshy basally, tapering to a fine tip, as long as posterior 6–8 segments (fig. 10b). Setae with 2 large teeth slightly unequal in size and many small teeth in 6–8 tiers (pl. 3a).

Remarks. The description above agrees well with that of Hartman (1951). The paratypes are similar except that the posterior parapodia are not grossly inflated as in the gravid holotype, nor are the dorsal cirri of segment 2 cirriform as in the holotype; in the paratypes they are lanceolate lobes, similar in shape, but smaller than those of subsequent segments.

Distribution. Maine to Gulf of Mexico, east coast of USA (Pettibone, 1963).

Hypereteone lighti Hartman comb. nov.

Figures 11a–d; 14j

Eteone lighti Hartman, 1936a: 127, 130, figs 36–39. Central California.

Material examined. USA, California, San Francisco Bay, Mar 1935, coll. and don. O. Hartman, USNM 20333, 2 syntypes of *Eteone lighti* and SEM stub NMV F53941 segment 11 parapodium from entire of 2 syntypes (2 labels read "type" in Hartman's hand-writing and a third USNM label reads "holotype" but the vial contains 2 specimens, thus these and the paratypes said by Hartman (1936a) to have been deposited in the AHF are all considered here to be syntypes).

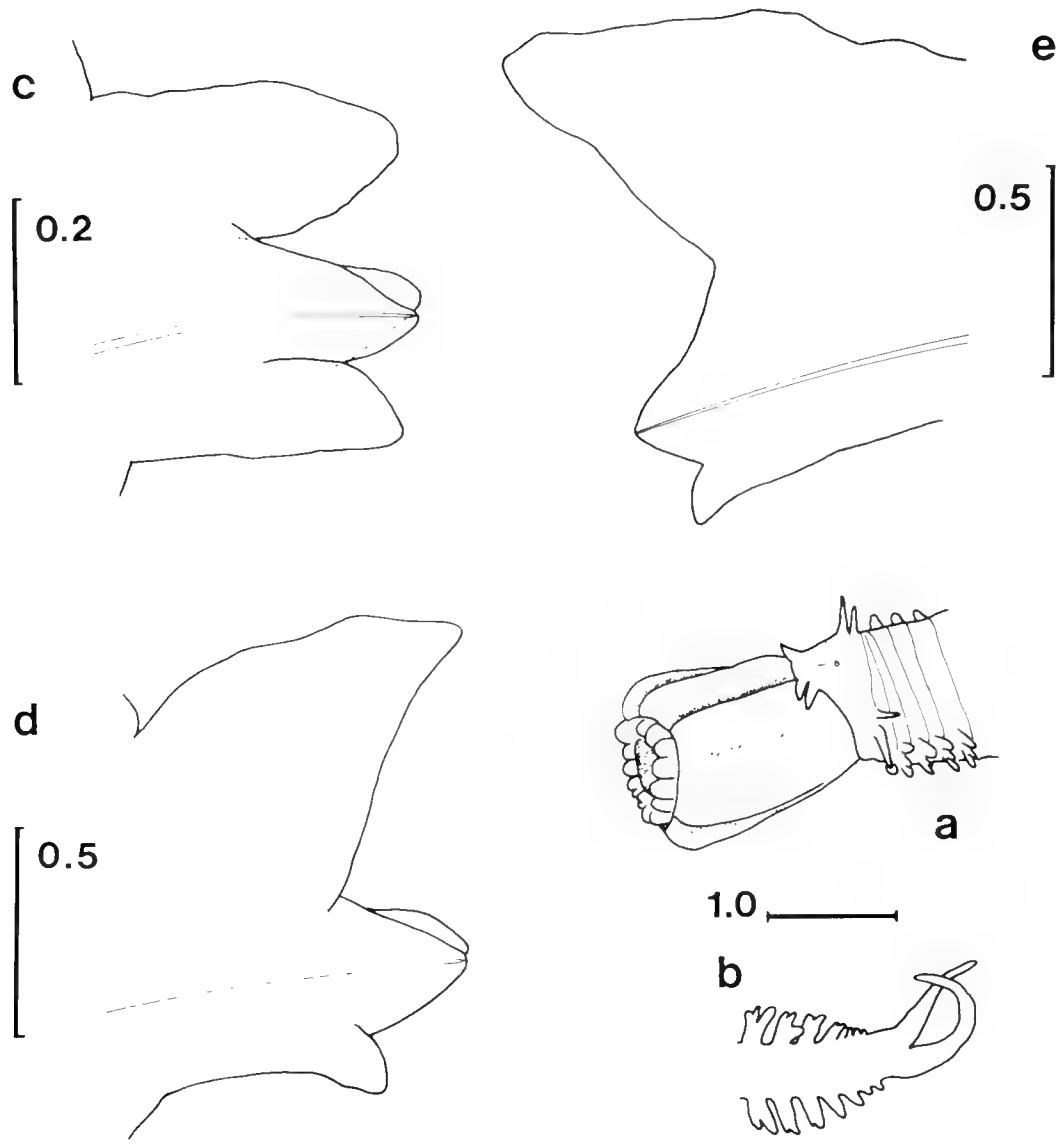

Figure 10. *Hypereteone heteropoda* AHF holotype: a, prostomium and everted proboscis dorsolateral view; b, anal cirri; c, setiger 10 parapodium posterior view; d, setiger 50 parapodium posterior view; e, setiger 100 parapodium anterior view. Scale bars in mm.

Description. (based on 2 syntypes of *E. lighti*) One entire specimen, 81 segments, almost broken between segments 59/60, 22 mm long, 0.6(1.0) mm wide. Second syntype an anterior fragment of 42 segments, 16 mm long, 1.0(1.6) mm wide. Colour pale yellow with no markings or patterns. Prostomium shorter than maximum width, narrow for two-thirds of length anteriorly, quickly broadening to become 3 times as wide posteriorly. Antennae not quite as long as anterior width of prostomium. Dorsal pair of antennae terminally located, ventral pair located posteriorly to first pair. Eyes a pair of faint red subdermal pigmented patches on posterior third of prostomium. Prostomium with continuous median dorsal groove (fig. 11a). Nuchal papilla not visible. Proboscis (not proviously dissected) examined by ventral dissection in both syntypes, smooth internally, and without papillae but with faint longitudinal striations and raised dorsal ridge distally. Probosces

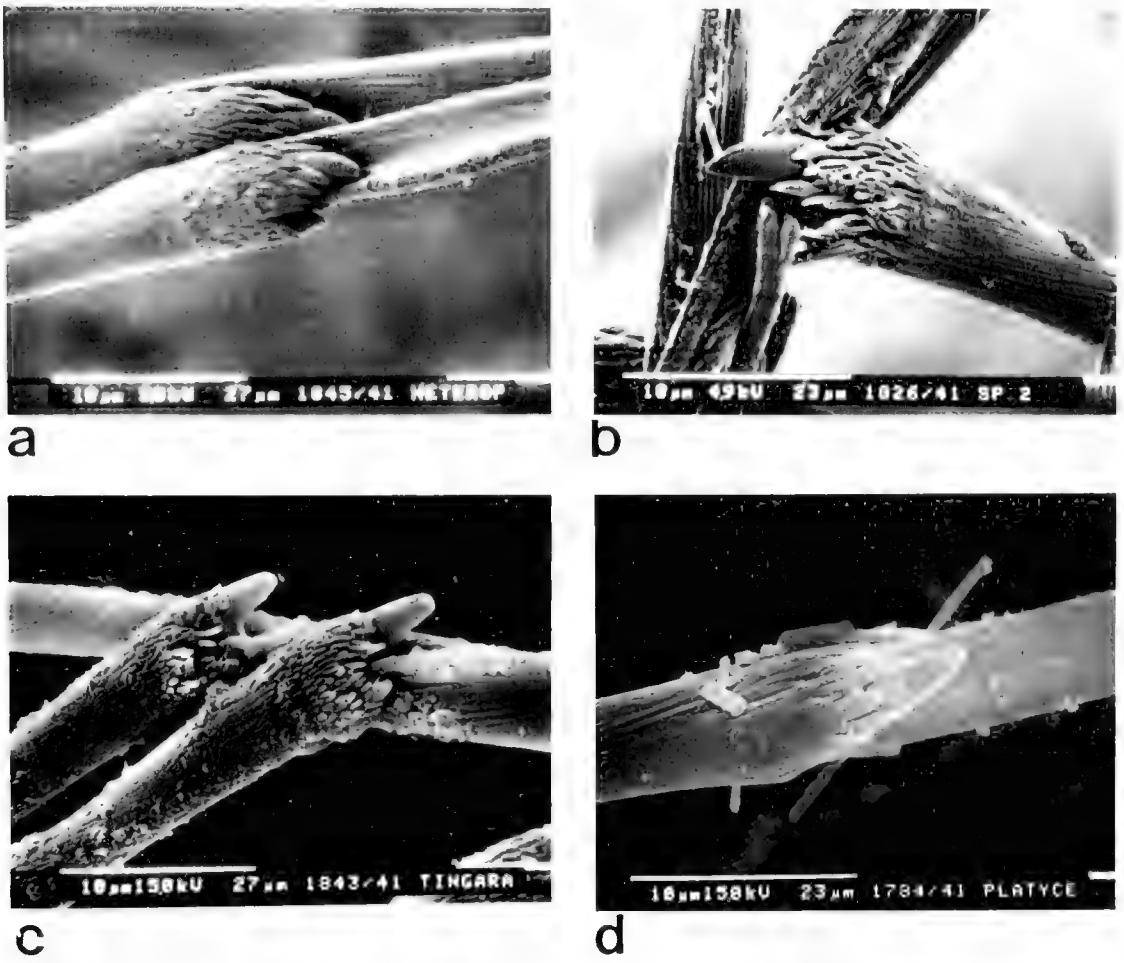

Plate 3. Scanning electron mmicrographs of species of *Hypereteone* and *Mysta*. a, *H. heteropoda* AHF holotype (from setiger 10); b, *H. tingara* AM W201453 paratype (from setiger 25); c, *H. tingara* NMV F52623 holotype (from setiger 30); d, *M. platycephala* NMV F52623 (from median setiger). Scale bars in μm.

extend back to segments 5–7. Tentacular cirri of similar length, about quarter width of first segment. Second segment with setae, reduced ventral cirri and neuropodia. Segment 3 with triangular acuminate dorsal cirri, rounded neuropodia and smaller triangular ventral cirri. Dorsal cirri becoming ovoid with rounded tips, parapodial lobes similar in proportion on all subsequent segments but each segment becoming longer in proportion to width from segments 20–25 (figs 11c, d). Anal cirri as long as posterior 5 segments, tapering to fine point (fig. 11b). Setae with pair of large teeth equal in size and several smaller teeth in 2 or 3 tiers (fig. 14j).

Remarks. The above description agrees closely with that of Hartman, 1936a.

Distribution. California, west coast of North America.

Hypereteone otati sp. nov.

Figures 11e–h; 14k

Material examined. Holotype: Queensland, between Round Point and Rodney Island, Cape York, intertidal sand flats, 15 Feb 1985, P. Saenger, AM W201455, SEM stub NMV F53942 segments 98–101.

Description. Holotype a complete worm in 2 fragments for a total of 234 segments, 50 mm long, 0.7(1.0) mm wide. Colour in alcohol bright yellow with narrow longitudinal brown stripe on dorsum of anterior 50–55 segments; dorsal cirri of all but anterior 10 segments also with brown pigmentation.

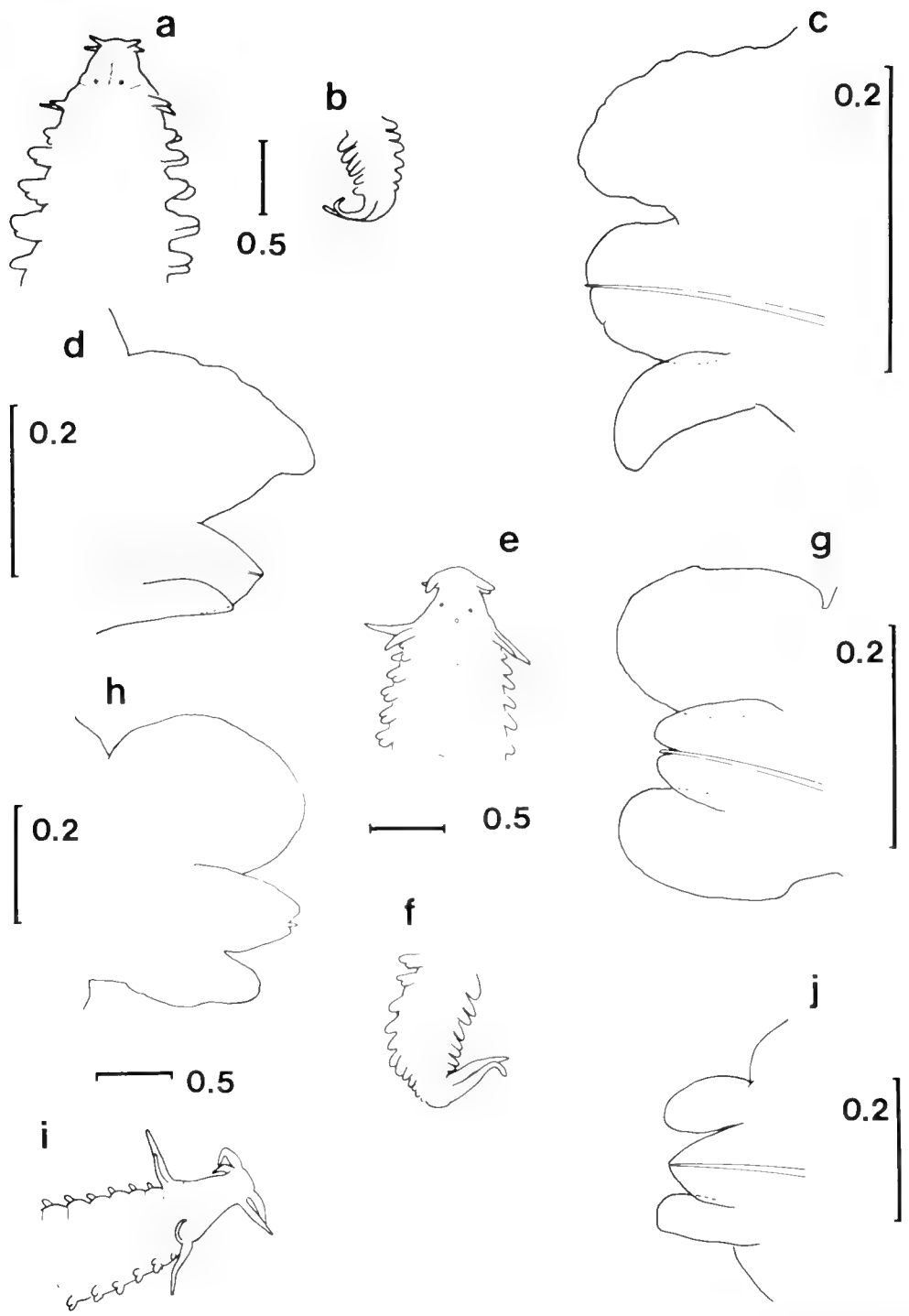

Figure 11. a, *Hypereteone lighti* larger of 2 syntypes USNM 20333 prostomium dorsal view. b–d, *Hypereteone lighti* smaller of 2 syntypes USNM 20333: b, anal cirri; c, setiger 10 parapodium anterior view; d, setiger 50 parapodium posterior view. e–h, *Hypereteone otati* AM W201455 holotype: e, prostomium dorsal view; f, anal cirri; g, setiger 11 parapodium anterior view; h, setiger 70 parapodium posterior view. i, j, *Hypereteone tingara* NMV F52623 holotype: i, prostomium dorsolateral view; j, setiger 20 parapodium anterior view. Scale bars in mm.

Prostomium as long as wide, anterior margin rounded, about half width of posterior margin, 1 pair of dark subdermal eyes and faintly visible nuchal papilla (fig. 11e). Proboscis extending back 18 segments, with 4 longitudinal rows of irregular tuberculae, dorsal row 2 tuberculae wide except for extreme distal region where single row is present, otherwise all ridges comprised of single rows of papillae. Proboscis with terminal ring of about 12 large papillae and pair of large lateral papillae. Dorsal pair of tentacular cirri about as long as width of first segment, and two-thirds as long as ventral pair. Second segment with ovoid ventral cirri similar in size to those of subsequent segments; setae, neuropodia and dorsal cirri absent. Third segment with a few setae, ovoid dorsal and ventral cirri similar in size, and barely visible rudimentary neuropodial lobe. Neuropodia gradually increasing in size until about as long as ventral cirri by segments 10–15. Neuropodia strongly bifid, with conspicuous brown tips of aciculae projecting slightly. Neuropodia slightly exceeding length of ventral cirri on median segments, reducing on posterior segments so that ventral cirri are slightly longer. Dorsal cirri initially ovoid, symmetrical and about equal to ventral cirri in size, by segment 40–50 becoming broader, ovoid to circular, asymmetrical and exceeding length of ventral cirri. Dorsal cirri similar in size and shape and larger than ventral cirri on posterior segments (figs 11g, h). Anal cirri long, cirriform, as long as posterior-most 5 or 6 segments (fig. 11f). Setae with 1 large tooth on 1 side of blade and many small teeth in 4 or 5 densely-packed tiers (fig. 14k).

Remarks. Hypereteone otati is most similar to *H. foliosa* as described above. Aside from the differences in colouration (live and recently preserved specimens of *H. foliosa* are a uniform cream-white, Pleijel, in prep.), *H. otati* can also be distinguished from the related species by the structure of the proboscis, which has fewer tuberculate ridges and terminal papillae than *H. foliosa* and the dorsal and ventral cirri which are both broader in *H. foliosa*. The two species can also be distinguished by the setae: only one large tooth is visible in *H. otati* whereas two unequal teeth are present in *H. foliosa*.

Etymology. The specific name *otati* is derived from the name of the Aboriginal tribe which once inhabited the type locality, and is to be treated as indeclinable.

Distribution. Recorded only from Cape York, northern Australia.

Hypereteone tingara sp. nov.

Figures 11i, j; plates 3b, c

Material examined. Holotype: Australia, Victoria, Western Port, 38°22.28′S, 145°30.24′E, stn WBES-1734, 5 m, sand, 29 Nov 1973, NMV F52623 and SEM stub NMV F53944 segment 31 RHS parapodium.

Paratypes: Victoria, Bass Strait, 112 km S of Lakes Entrance, 39°00′S,148°24.8′E, Esso-Gipps Stn 20, 95 m, sand, May 1969, C. Phipps, AM W201454, paratype. Tasmania, off St Helens Point, 41°20.6′S, 148°30′E, BMR stn 573-2038, 110 m, fine clayey sand, 25 Mar 1973, P.H. Coleman on R.V. "Sprightly", AM W201453, paratype and SEM stub NMV F53943 segment 26 RHS parapodium.

Description. The holotype is an anterior fragment, 52 segments, 11 mm long, 0.9 (1.0) mm wide. Size range of paratypes: 53 segments, 8 mm long and 81 segments, 10 mm long; both anterior fragments 0.4 (0.6) mm wide. Body uniform pale yellow throughout, no obvious markings or pigment patterns. Prostomium twice as long as maximum width, tapering to narrow rounded point anteriorly, width at anterior margin half that at posterior margin. Neither eyes nor nuchal papilla visible. Antennae equal in length, about 1.5 times anterior width of prostomium. Dorsal pair of antennae terminal, ventral pair slightly posterior to first pair (fig. 11i). First segment fused to prostomium dorsally, a slight division visible laterally and extending ventrally to buccal opening. Ventral pair of tentacular cirri as long as breadth of first segment, dorsal pair narrower and two-thirds as long as ventral pair. Proboscis, examined through ventral dissection, extends back internally to segment 15, damaged in dissection but with 3 (or possibly 4) longitudinal rows of large low rugose papillae, each row 1 papilla wide, proboscis apparently smooth between rows. Second segment without dorsal cirri, neuropodia, or setae; only with small ovoid ventral cirri. Third segment with setae, flattened digitiform dorsal cirri and neuropodium and ovoid ventral cirri. Dorsal cirri and neuropodia of about first 10 segments similar in length, ventral cirri slightly longer (fig. 11j). Ventral cirri and neuropodia exceeding dorsal cirri in length from about segment 25 and posteriorly. Body narrows significantly over anterior 10 segments, approximately constant in width posteriorly but segments noticeably more deeply divided posterior to about segment 30. Anal cirri unknown. Setae with pair of large teeth unequal in size and 3 or 4 tiers of smaller teeth (pls 3b, c).

Remarks. This species is placed in the genus *Hypereteone* on the basis of the characteristic struc-

ture of the proboscis and prostomium and the proportions of the tentacular cirri, all of which agree with the other species in the genus. The anal cirri are unknown since all specimens are incomplete posteriorly; when more specimens are collected *H. tingara* should be found to possess long cirriform anal cirri in agreement with the generic definition.

Hypereteone tingara is similar to two other species of *Hypereteone* in which the prostomium is also longer than its maximum width: *H. aestuarina* and *H. fauchaldi*. *Hypereteone tingara* can be distinguished from both species by the absence of setae on segment 2 and the ventral cirri which are larger than the dorsal cirri on posterior segments (in *H. aestuarina* and *H. fauchaldi* setae are present on segment 2 and the dorsal cirri are larger than or similar in size to the ventral cirri on posterior segments).

Hypereteone tingara can be distinguished from the only other Australian species in the genus, *H. otati*, by the colouration, which is bright yellow in *H. otati*; the prostomium and antennae which are more elongate in *H. tingara*; and the dorsal cirri, which are smaller and narrower in *H. tingara*.

Hypereteone tingara appears to be uncommon and is only known from three specimens from south-eastern Australia despite several major benthic surveys of coastal bays and the continental shelf in the region.

Etymology. The specific name *tingara* is derived from an Australian Aboriginal word meaning the sea, and is to be treated as indeclinable.

Distribution. South-eastern Australia: Victoria, Bass Strait and Tasmania.

Hypereteone sp.

Eteone ornata. – Day, 1967: 140, fig. 5.1f–i (not Grube, 1878).

Remarks. Day's (1967) description (proboscis with three to four longitudinal rows of papillae, ventral cirri longer than dorsal cirri, and setae lacking on second segment) clearly places this apparently undescribed species in the genus *Hypereteone* as defined in this paper.

Distribution. Mozambique.

Genus **Mysta** Malmgren, 1865

Diagnosis. Phyllodocidae with 2 pairs of antennae. 2 pairs of tentacular cirri on first segment. Segment 2 lacking dorsal cirri. Eversible proboscis with 2 lateral rows of leaf-like papillae, 1 row on each side of proboscis, proboscis dorsally with band of small spinose papillae. Anal cirri digitiform with blunt rounded tips, up to 4 times as long as maximum width.

Type species. Mysta barbata Malmgren, 1865, by monotypy.

Remarks. The diagnosis above follows the concept of Uschakov (1974) and Fauchald (1977).

Key species of the genus *Mysta*

The key excludes two poorly-known species: *M. syphodonta* delle Chiaje and *Mysta* sp. which appear to be valid species (see species accounts below) but cannot be distinguished on the basis of available published descriptions; if included both species would key out as far as couplet 5.

1. Dorsal cirri circular to kidney-shaped, width equal to or exceeding length 2
– Dorsal cirri ovoid, longer than wide 3
2. Proboscis with more than 20 large papillae on each side; dorsal pair of tentacular cirri much longer than ventral pair ..... *M. barbata*
– Proboscis with fewer than 10 large papillae on each side; dorsal pair of tentacular cirri equal to or only slightly longer than ventral pair *M. picta*
3. Orifice of proboscis with 1 large teat-like papilla situated dorsally .... *M. tchangsii*
– Orifice of proboscis without large teat-like papilla 4
4. Dorsum with 3 distinct dark violet longitudinal stripes ..... *M. ornata*
– Dorsum without distinct violet longitudinal stripes 5
5. Lateral rows of papillae extend over almost the full length of the proboscis; dorsal tentacular cirri equal to or only slightly longer than ventral .... *M. platycephala*
– Lateral rows of papillae confined to basal half of the proboscis; dorsal tentacular cirri much longer than ventral ..... *M. maculata*

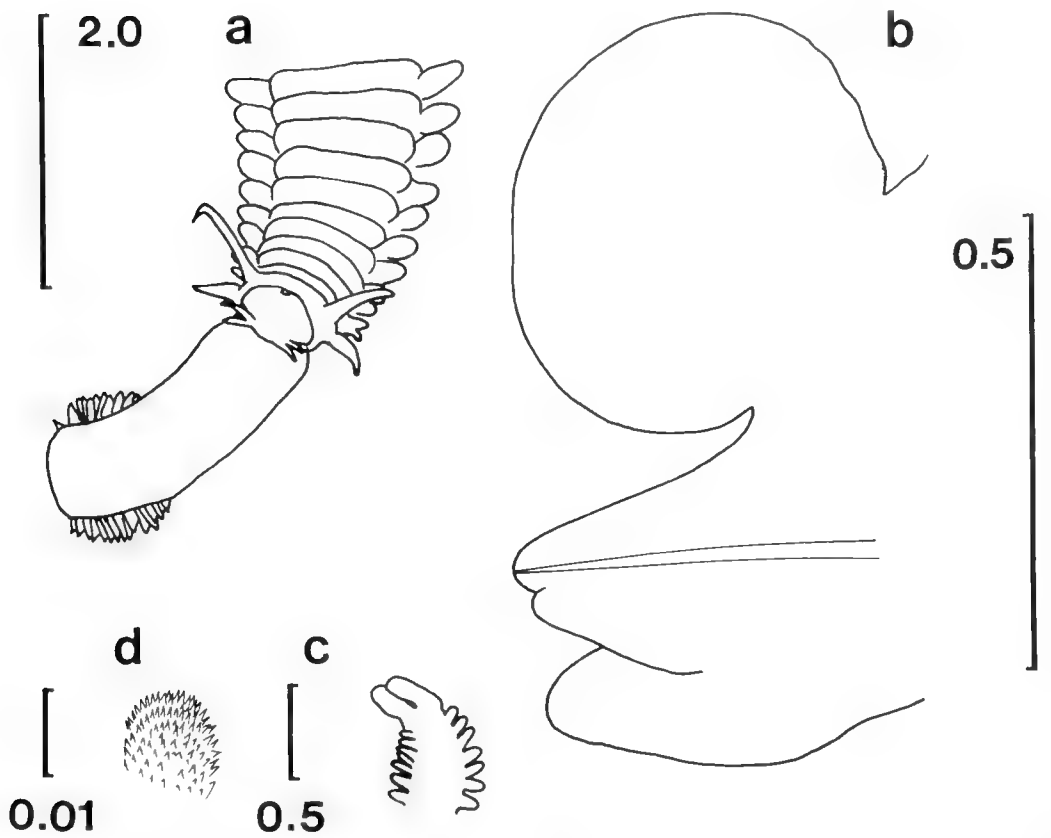

Figure 12. a, b, *Mysta barbata* SMNH 2417 holotype: a, prostomium and everted proboscis; b, setiger 25 parapodium anterior view. c, d, *Mysta papillifera* SMNH 2418 syntype: c, anal cirri; d, spinose pad from dorsum of proboscis. Scale bars in mm.

Mysta barbata Malmgren

Figures 12a–d; 14l

Mysta barbata Malmgren, 1865: 101, pl. 15 figs 34, 34a–34d.

Mysta papillifera Théel, 1879: 33, 34, pl. 2 figs 25–28.

Material examined. Sweden, Bohuslan, Gullmaren, A.J. Malmgren, SMNH 2417, syntype of *Mysta barbata* and SMNH SEM stub setiger 21 parapodium.

USSR, Arctic Ocean, Novaya Zemlya, Cap Grebeni, 29–31 Jul 1875, coll. Stuxb. and Théel, SMNH 2418, syntypes of *Mysta papillifera*, 2 entire specimens and 3 fragments; 4 or 5 separate specimens may be represented.

Description. Syntype of *Mysta barbata* in 4 fragments: anterior fragment of 25 segments, 6.5 mm long (excluding everted proboscis), 1.2 (2.0) mm wide; fragment almost complete posteriorly but lacking anal cirri, 142 segments, at least 40 mm long; plus 2 transverse sections of a single and a pair of median segments. Prostomium 1.5 times as long as maximum width at posterior margin, width at anterior margin half width at posterior margin. Dorsal pair of antennae about as long as anterior width of prostomium, ventral pair of antennae slightly shorter. Neither eyes nor nuchal papilla visible, though distinct pit situated mid-dorsally on posterior margin of prostomium (fig. 12a). Proboscis approximately half-way everted, about as long as 14 anterior segments, ventral dissection reveals lateral row of over 40 triangular papillae along each side of distal third of the prostomium (fig. 12a). Proboscis dorsally with numerous minute papillae in transverse rows, each papilla with pad of 40–50 curved teeth (fig. 12d), smooth elsewhere. Dorsal pair of tentacular cirri about as long as width of first setiger, ventral pair two-thirds as long and slightly thicker basally. Second segment with setae, lanceolate neuropodia and ventral cirri, about equal in length. Dorsal cirri present from segment 3, about as long as neuropodial lobes initially and flattened digitiform, becoming ovoid to circular on subsequent segments, almost circular

from setiger 20 (fig. 12b). Neuropodia and ventral cirri similar in size and shape throughout but relatively shorter than dorsal cirri posterior to setiger 20. Anal cirri lost from holotype. Setae with pair of large teeth slightly unequal in size and rows of successively smaller teeth at base of large tooth (fig. 14l).

Remarks. The syntypes of *Mysta papillifera* are smaller specimens in which the probosces are fully retracted; these specimens agree in every respect with the description of *M. barbata* except that the dorsal tentacular cirri are slightly longer than in the holotype of *M. barbata*. The anal cirri (missing from the holotype) consist of a pair of rounded digitiform lobes about three times as long as wide. *Eteone striolata* Levinsen, 1882 (junior homonym, not Bobretsky, 1868) was synonymised with *M. barbata* by Hartman (1959).

Distribution. Recorded from Arctic Ocean, North Sea, Sea of Okhotsk, Sea of Japan (Pleijel, in prep.).

Mysta maculata Treadwell

Figures 13a–d; 14m

Mysta maculata Treadwell, 1920: 593, 594, figs 1–4. Phillipines.

Material examined. Phillipines, Sulu Archipelago, Sulade Island, vicinity of Siasi, "Albatross" stn 5146, 24 fm [44 m], coral sand and shell bottom, 16 Feb 1908, USNM 18940, holotype, SEM stub NMV F53945, segment 21 LHS parapodium.

Description. The holotype is an anterior fragment of 140 segments, about 50 mm long, 2.0 (2.5) mm wide at setiger 11. Colour in alcohol pale brown with dark spots in some dorsal cirri and scattered points of dark brown pigmentation on dorsum. Prostomium lens shaped, twice as wide as long, anterior margin of prostomium half as wide as maximum width of prostomium, which occurs in mid-section. Antennae as long as width of prostomium at anterior margin. Only dorsal pair of antennae visible from above, ventral pair, which are slightly stouter, can be seen only in ventral view. One pair of dark subdermal eyes close to posterior margin of prostomium. Nuchal papilla absent (fig. 13a). Proboscis retracted, extends back internally to setiger 16, with about 18 large discoid papillae on each side forming 2 lateral rows over basal half of proboscis, distal half being free of lateral papillae. Dorsal surface of proboscis carries dense band of minute small denticulate papillae in transverse rows, each papilla with 40–50 long teeth (fig. 13b). Ventral surface of proboscis without papillae. Ventral pair of tentacular cirri half as long as width of first segment, dorsal pair slightly longer than ventral pair. Second segment with setae, lanceolate ventral cirri and neuropodium of equal length. Dorsal cirri present from segment 3, initially ovate and of similar length to neuropodia, becoming broader and attached by distinct stalk by setiger 10. Dorsal cirri circular to ovate and extending as far as neuropodia on all subsequent segments. Neuropodia and ventral cirri lanceolate lobes, similar in shape and length throughout all segments (figs 13c, d). Anal cirri unknown. Setae with 1 large tooth and 2 rows of successively smaller teeth (fig. 14m).

Remarks. Mysta maculata is similar to *M. platycephala* from Australian waters but differs in the relative lengths of the dorsal and ventral tentacular cirri which are equal in *M. platycephala* but unequal in *M. maculata*, the teeth on the dorsal band of proboscidial papillae which are longer and more numerous in *M. maculata*, and in the ventral cirri which are reduced to a small lobe in *M. platycephala* whereas in *M. maculata* the ventral cirri and neuropodia are similar and equal in size throughout.

Distribution. Known only from the holotype, Sulu Archipelago, Phillipine Islands.

Mysta ornata (Grube)

Eteone ornata Grube, 1878 [not seen]. – Izuka, 1912: 201.

Mysta ornata. – Imajima and Hartman, 1964: 65, 66. – Uschakov, 1974: 172, pl. 18 figs 1–4.

Remarks. The following description is abstracted from Uschakov (1974): Dorsum with 3 brown-violet longitudinal stripes. Proboscis with 2 lateral rows of papillae. Dorsal tentacular cirri slightly longer than ventral tentacular cirri. Dorsal cirri ovoid, longer than wide and attached by distinct pedicel; ventral cirri slightly longer than neuropodia. Setae with 2 large teeth and a number of smaller teeth at the articulation. Anal cirri large, about twice as long as wide.

Izuka (1912) and Uschakov (1974) agreed that the conspicuous dorsal stripes distinguish *Mysta ornata* from related species. Uschakov's (1974) record appears to be only the second valid record of this species (the records of Fauvel, 1932, 1933, 1953b and Day, 1967 were referred to other species by Uschakov).

Distribution. Known only from the original description and a subsequent record (Peter the Great Bay), both in the northern Sea of Japan.

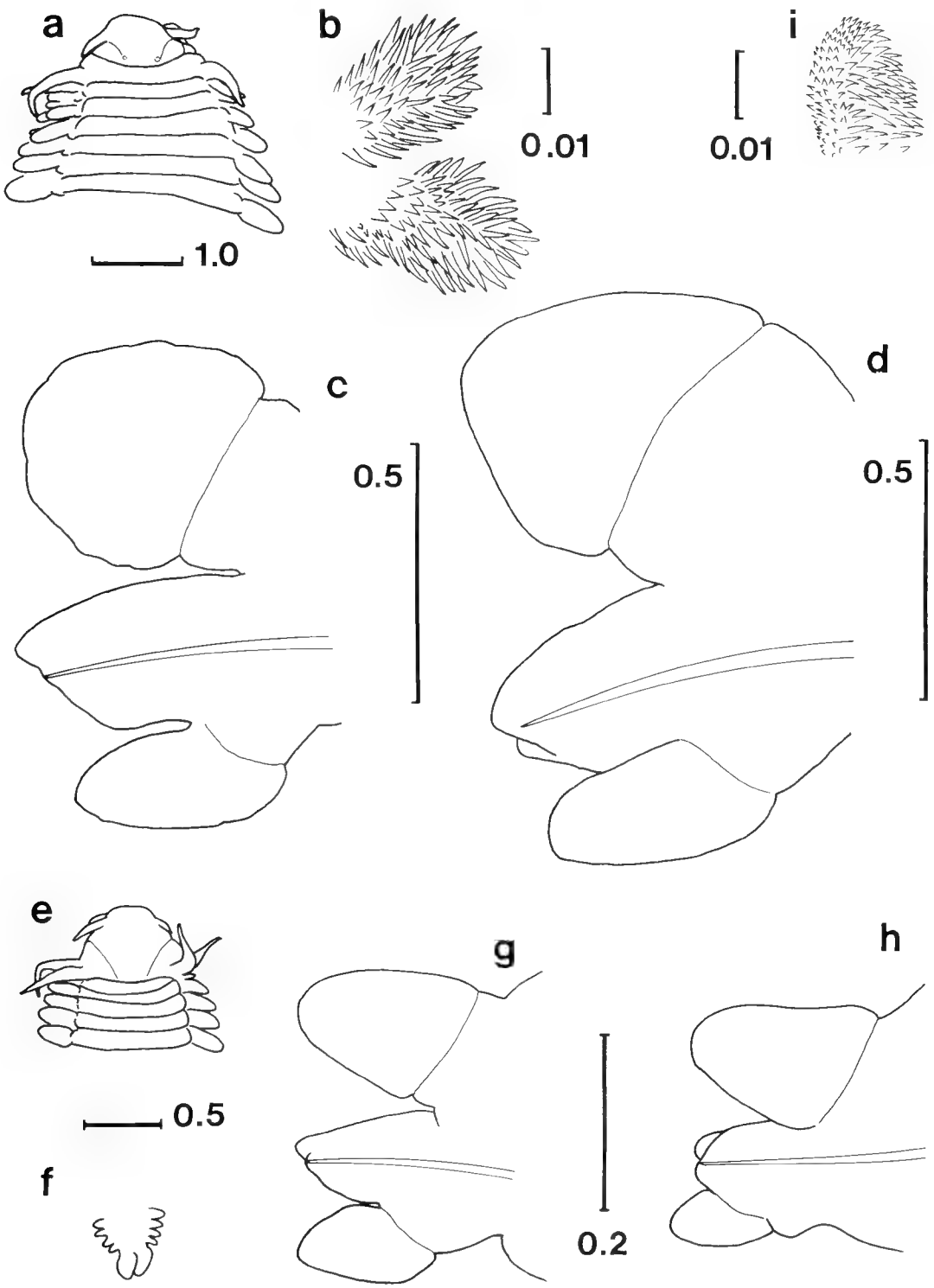

Figure 13. a–d, *Mysta maculata* USNM 18940 holotype: a, prostomium dorsal view; b, spinose pads from proboscis; c, setiger 10 parapodium posterior view; d, setiger 50 parapodium posterior view. e–h, *Mysta platycephala* HZM V-7928 syntype: e, prostomium dorsal view; f, anal cirri; g, setiger 11 parapodium anterior view; h, setiger 50 parapodium anterior view. i, *Mysta platycephala* NMV G1889 spinose pad from proboscis. Scale bars in mm.

Mysta picta Quatrefages

Eteone picta Quatrefages, 1865: 147, pl. 18 figs 18–23. Brehat, Bretagne, France.

Eteone (Mysta) picta.—Fauvel, 1923: 176, 177, figs 64a–g.

Remarks. The following description is taken from Fauvel, 1923: Proboscis with 2 lateral rows of large papillae, dorsal band of small denticulate papillae and a ventral semicircle of 20 lanceolate papillae. Dorsal and ventral tentacular cirri similar in length. Dorsal cirri circular to kidney shaped, wider than long except on posterior segments. Articulation of setae with pair of large teeth and series of smaller teeth. Anal cirri ovoid.

Bergström (1914) was uncertain as to whether *Mysta picta* was synonymous with *M. syphodonta*, however the form of the dorsal cirri, which are longer than wide in *M. syphodonta* but circular to kidney-shaped in *M. picta*, readily separate the two species; the two were regarded as distinct species by Fauvel (1923) and Uschakov (1974). Hartman (1959) synonymised *Eteone armata* Claparède, 1868, *E. incisa* Saint-Joseph, 1888 and *E. striata* Bobretzky, 1868 with *Mysta picta*, and the same author also treated *E. geoffroyi* (Audouin and Milne-Edwards, 1834) as a questionable synonym of *M. picta*.

Distribution. Mediterranean, Atlantic coast of France and English Channel (from Fauvel, 1923).

Mysta platycephala (Augener) comb. nov.

Figures 13e–i; plate 3d

Eteone platycephala Augener, 1913: 136–138, pl. 3 figs 44, 45, text-figs 9a, b. Shark Bay, Australia.—Knox and Cameron, 1971: 23. Port Phillip Bay, Victoria.

Eteone sp. 1 Poore et al., 1975: 51. Port Phillip Bay, Victoria.

Material examined. Australia. Western Australia. North-west Shelf, 7 stations, 1982–1983, 39–88 m, coll. CSIRO, AM W200916–W200917, W200921, W200934, W200978–W200979, W200986, 7 specimens. North-west Shelf, 2 stations, 1983, 30–42 m, coll. CSIRO/Poore and Lew Ton, NMV F52624–F52625, 2 specimens. Shark Bay, NW of Middle Bluff, Stn 1, 7–8 m, 21 Sep 1905, HZM V-7928, 1 syntype. Mermaid Sound, Dampier Archipelago, Stn AC, 13 Feb 1981, coll. Meagher and assoc., WAM 32-86, 1 specimen.

South Australia. Upper Spencer Gulf, stn B10, 16 Sep 1973, S. Shepherd, AM W5986, 1 specimen. Spencer Gulf, 16 km SW of First Creek, Port Pirie, 1980, coll, T.J. Ward and P.C. Young, subtidal *Posidonia*, 2.8 m, AM W202402, W202445, 2. Spencer Gulf, 8 km SW of First Creek, Port Pirie, 1979, coll. T.J. Ward and P.C. Young, bare sediment, 13.4 m, AM W202446, 1.

Victoria. Port Phillip Bay; Port Phillip Survey Area 5 Stn 169 (see Black, 1971 for habitat data), NMV G1889, 1 specimen (material of Knox and Cameron, 1971); 4 km ENE of Point Wilson, MMBW Stn B2, 19 Apr 1983, NMV F52626, 2 specimens; PPBES stn 913, 10 Jun 1971, NMV F52627, 1 specimen; PPBES stn 922, 10 Jun 1971, NMV F52628, 1 specimen; PPBES stn 928, 2 Nov 1972, NMV F52629, 1 specimen; PPBES stn 985, 9 Dec 1971, NMV F52630–F52632, 4 specimens and SEM stub NMV F53946 whole mount of 1 of 2 specimens from NMV F52632; (PPBES material - *Eteone* sp.1 of Poore et al., 1975; see Poore, 1986 for full locality details). Eastern Victoria; LVWSB SWOP81 stn 1281, coll. Marine Science and Ecology (Vic.), 1 specimen.

New South Wales. Murrays Basin (NSW State Fisheries collections): stn 40, Apr 1972, AM W194234, 1 specimen; stn 154, sand, 17 Oct 1972, corer, AM W194489, 2 specimens; stn 165, sandbank, 17 Oct 1972, corer, AM W194276, 1 specimen; stn 169, sand, 17 Oct 1972, corer, AM W194301, 2 specimens; stn 185, sandbank, 9 Oct 1972, AM W194424, 4 specimens.

Queensland. Gladstone Harbour, site 19, dredge, 6 Nov 1975, coll. P. Saenger, QM GH3571, 1 specimen; Peel Island, Moreton Bay, 0.8 km S of wrecks, 7.6 m, sand-shell-grit, Sep 1970, QM G10438, 1 specimen. Middle Banks, northern Moreton Bay: grab, Jul/Aug 1982, coll. I. Poiner, QM GH3595, 3 specimens; grab, Nov 1983–Nov 1984, coll. P. Saenger and S. Cook, QM GH3611, 2 specimens; stn 33, grab, 11.6 m, sand, Dec 1973, QM GH3652, 1 specimen; stn 28, grab, 21 m, sandy-mud, coll. S. Cook, Dec 1973, 1 specimen; stn 47, grab, 29 m, mud, Jun 1973, coll. S. Cook, QM GH3679, 1 specimen; stn 51, grab, 30.5 m, mud, Mar 1974, coll. S. Cook, QM GH3650, 1 specimen.

Description. Size range of material examined: 58 segments, 5.5 mm long, 0.3 (0.4) mm wide at segment 10 to 164 segments, 40 mm long, 0.9 (1.4) mm wide (entire specimens). Prostomium trapezoid, two-thirds as long as wide, strongly dorsoventrally flattened, with rounded anterior margin, partly enclosed posteriorly by lateral expansion of first segment. Prostomium thus achieves maximum width in median region, anterior and posterior margins both about half maximum width. 2 pairs of antennae anteriorly located and most easily seen in ventral view, as long as anterior width of prostomium. Eyes not visible in type material but 1 pair of red eyes close to posterior margin of prostomium present in most other specimens. No nuchal papilla (fig. 13e). Tentacular cirri equal in length or with dorsal pair slightly longer than ventral pair and about two-thirds as long as width of first segment. Proboscis (retracted in all specimens) extends back to about segment 12, with row of 10–15 triangular papillae along each side (10 in the syntype examined here), papillae largest in median regions, smaller at either end of row and extending over almost full length of proboscis excepting only extreme basal

and distal ends. Proboscis also with dorsal band of small papillae arranged in transverse rows, each papilla with about 20 long teeth (fig. 13i). Conspicuous fleshy "gizzard-like" structure follows proboscis and extends back to about setiger 18. Second segment with setae, conical neuropodia and ventral cirri both with rounded tips, ventral cirri about twice as long as neuropodia. Dorsal cirri present from segment 3, carried on short pedicel, triangular-lanceolate in shape with rounded tips and of similar length to other lobes on anterior segments, slightly longer and larger than neuropodia and ventral cirri on median and posterior segments. Neuropodia and ventral cirri lanceolate lobes from setiger 3, similar in size and proportions on all subsequent segments (figs 13g, h). Anal cirri digitiform, about 3 times as long as wide (fig. 13f). Setae with pair of large teeth at articulation and 2 rows of successively smaller teeth (pl. 3d).

Remarks. Augener (1913) stated that he had two specimens before him on which the original description was based: one entire specimen and one posterior fragment with the head missing. The type specimen examined here is therefore one of two syntypes, albeit the only specimen complete with a head. The number of segments and dimensions agree exactly with Augener (1913). The structure of the proboscis has not previously been described and the syntype had not been dissected to reveal the proboscis prior to my examination of the specimen. Two specimens from Spencer Gulf, South Australia (AM W202402, W202445), have abnormal probosces: each paired row of triangular papillae is fused into a longitudinal fleshy ridge. These two specimens are identical in other respects (the form of the prostomium, parapodia and setae) to the remaining material and I have concluded that the abnormality of the proboscis is of no taxonomic significance. Except for occasional variations in pigmentation (some specimens have a single broad brown transverse band on the dorsum of segments 4-6) all material otherwise agrees with the type specimen and original description of Augener, 1913.

The form of the proboscis, prostomium, dorsal cirri and setae clearly place this species in the genus *Mysta* and *M. platycephala* is thus proposed here as a new combination.

Distribution. Widespread in Australia: northwestern Australia, Victoria, and Queensland, particularly from embayments and inshore waters (but not collected during an extensive survey of the continental shelf of Bass Strait, south-eastern Australia—Wilson and Poore, 1987). Variety of sediments, 2–88 m. Also recorded from New Zealand (Augener, 1924: 308; Augener, 1927: 344).

Mysta syphodonta (delle Chiaje)

Lumbricus syphodonta delle Chiaje, 1822 [not seen] Gulf of Naples.

Eteone (Mysta) siphonodonta (sic.).—Fauvel, 1923: 178, fig. 63e-h.

Mysta siphonodonta (sic.).—Bergström, 1914: 205–207, fig. 78a, b.

Remarks. Delle Chiaje's material appears to be lost (K. Fauchald, pers. comm.); the following brief description is taken from Fauvel (1923), who recognised *M. syphodonta* as distinct from *M. barbata* and *M. picta*. Proboscis with large papillae in 2 lateral rows, dorsal band of small denticulate papillae and narrow ventral band of small papillae. Dorsal tentacular cirri longer than ventral. Dorsal cirri ovoid, longer than wide and asymmetrical. Articulation of setal shafts with pair of large teeth and series of smaller teeth.

Distribution. Mediterranean and Adriatic Seas (Fauvel, 1923); recorded from the Black Sea by Mikashavidze (1981).

Mysta tchangsii Uschakov and Wu

Eteone (Mysta) tchangsii Uschakov and Wu, 1959: 8. Yellow Sea, China.—Uschakov, 1974: 173, 174, pl. 19 figs 1-6.

Eteone (Mysta) ornata.—Fauvel, 1933: 17, 18 fide Uschakov, 1974 (not Grube, 1878).

Remarks. The following brief description is taken from Uschakov and Wu (1979). Dorsum with violet coloured spots scattered irregularly, some specimens with blueish irredescent tinge. Prostomium without eyes, small nuchal papilla present; dorsal tentacular cirri longer than ventral pair. Proboscis with lateral rows of large papillae over all but the extreme basal section, orifice with single large teat-like papilla dorsally and surrounded by ring of small digitiform papillae. Dorsal cirri ovoid and carried on large pedicels. Setae with 2 large teeth unequal in size and series of smaller teeth.

According to Uschakov (1974) and Uschakov and Wu (1979) *Mysta tchangsii* differs from *M. ornata* and *M. syphodonta* only in coloration, but the description provided by Uschakov and Wu suggests that the large dorsal papilla at the orifice of the proboscis and the setae with large teeth of unequal size also distinguish this from related species.

Distribution. Yellow Sea and South China Sea, China and India (Uschakov, 1974).

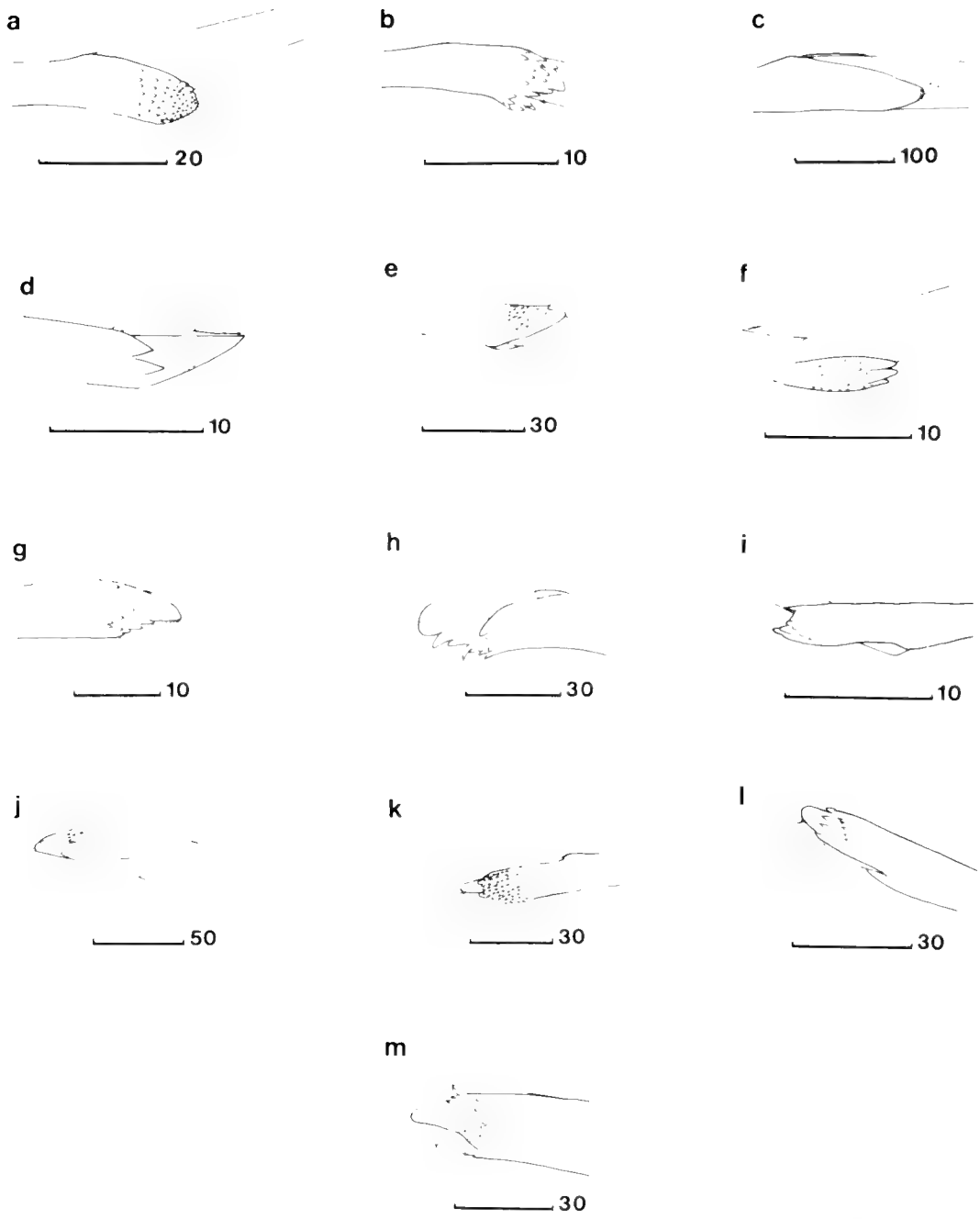

Figure 14. Setae of species of *Eteone*, *Hypereteone* and *Mysta*. a, *E. balboensis* USNM 20337 holotype (from median setiger); b, *E. californica* USNM 20339 entire specimen of 2 syntypes (from setiger 15); c, *E. fucata* ZMO syntype (from median setiger); d, *E. japanensis* BMNH ZK1921.5.1.1059 holotype (from setiger 15); e, *E. sculpta* HZM V-1205 holotype (from setiger 27); f, *E. spilotus* USNM 57959 larger of 2 paratypes (from setiger 10); g, *E. trilineata* USNM 441 syntype (from setiger 11); h, *H. alba* USNM 493 lectotype (from setiger 10); i, *H. alba* USNM 493 larger of 2 paralectotypes (from setiger 10); j, *H. lighti* USNM 20333 entire specimen of 2 syntypes (from setiger 10); k, *H. otati* AM W201455 holotype (from about setiger 97–100); l, *M. barbata* SMNH 2417 holotype (from setiger 20); m, *M. maculata* USNM 18940 holotype (from setiger 20). Scale bars in μm.

Mysta sp.

Eteone (Mysta) siphodonta.—Day, 1967: 140, fig. 5.1a–e. False Bay to Natal, South Africa (not delle Chiaje, 1822).

Remarks. The following description is taken from Day (1967): Proboscis with large papillae in 2 lateral rows and dorsal band of small denticulate papillae. Dorsal tentacular cirri longer than ventral. Dorsal cirri ovoid, longer than wide. Articulation of setal shafts with pair of large teeth and series of smaller teeth.

Day (1967) found that South African material which he referred to *Mysta syphodonta* lacked the ventral band of proboscidial papillae which according to Fauvel (1923) are present in Mediterranean specimens. Day's fig. 5.1d indicates that the dorsal cirri are symmetrical in contrast to the asymmetrical dorsal cirri seen in material from the type locality. These differences indicate that the South African records may represent an undescribed species.

Distribution. South Africa, False Bay to Natal.

Key to Australian species of *Eteone, Hypereteone* and *Mysta*

1. Body of adult worms narrow, threadlike (c. 0.2 mm wide); anal cirri spherical globes ..... *Eteone filiformis*
— Adult worms not threadlike (>0.5 mm wide); anal cirri digitiform or cirriform 2
2. Setae present from second segment; anal cirri digitiform (no more than 4 times as long as wide) 3
— Setae present from third segment; anal cirri at least 5 times as long as wide, tapering to pointed tip ..... *Hypereteone* 5
3. Proboscis with 2 rows of lateral foliose papillae; dorsal cirri carried on distinct pedicel ..... *Mysta platycephala*
— Proboscis smooth basally, rugose distally, without lateral rows of papillae; dorsal cirri not carried on distinct pedicel 4
4. Dorsal cirri expanded posteriorly, becoming twice as long as ventral cirri; anterior dorsum with prominent transverse dark brown bars *Eteone palari*
— Dorsal cirri similar in length to ventral cirri throughout; dorsum without striking pigmentation ..... *Eteone tulua*
5. Length of prostomium equal to maximum width; dorsal cirri longer than ventral cirri on posterior segments; body coloured bright yellow ..... *Hypereteone otati*
— Prostomium twice as long as maximum width; ventral cirri longer than dorsal cirri on posterior segments; body pale cream-white *Hypereteone tingara*

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Appendix

Eteone nomina dubia

Eteone cylindrica Ørsted

Eteone cylindrica Ørsted, 1842: 122. Greenland.

Remarks. Eteone cylindrica was recognised by Hartman (1959) as a potentially valid species, however the original description is inadequate and the type material is apparently lost (F. Pleijel, pers. comm.); I regard this as a *nomen dubium*.

Eteone maculata Ørsted

Eteone maculata Ørsted, 1843: 29–30, figs 5, 6. Denmark.

Remarks. Nomen dubium. Poorly described and type material apparently lost (K. Fauchald and F. Pleijel, pers. comm.).

Eteone pusilla Ørsted

Eteone pusilla Ørsted, 1843: 30, fig. 84.

Remarks. Ørsted's original material cannot be located (K. Fauchald and F. Pleijel, pers. comm.). The original description is not sufficiently detailed to be confident of the specific identification, however the subglobular anal cirri described by Ørsted (1843) indicate that this species belongs to either *Eteone* or *Mysta* as defined in this paper.

Eteone setosa Verrill

Eteone setosa Verrill, 1873: 588. Massachusetts, USA.

Remarks. Pettibone (1963) synonomised *Eteone setosa* with *E. lactea*, which sould place Verrill's species in the genus *Hypereteone* as defined here. Verrill's types however remain lost (Hartman, 1942 and W.D. Hartman, pers. comm.) and I regard *E. setosa* as a *nomen dubium*.

Eteone tocantinensis Nolte

Eteone tocantinensis Nolte, 1938: 240. Atlantic Ocean, tropical.

Remarks. This species is dubiously placed in the genus *Eteone* since it has only a single pair of tentacular cirri. Known only from 6 setiger post-larval stage (other species of *Eteone* figured by Nolte (1938) have 2 pairs of tentacular cirri at earlier developmental stages).

Distribution. Equatorial Atlantic Ocean, latitude 48°30′W.

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